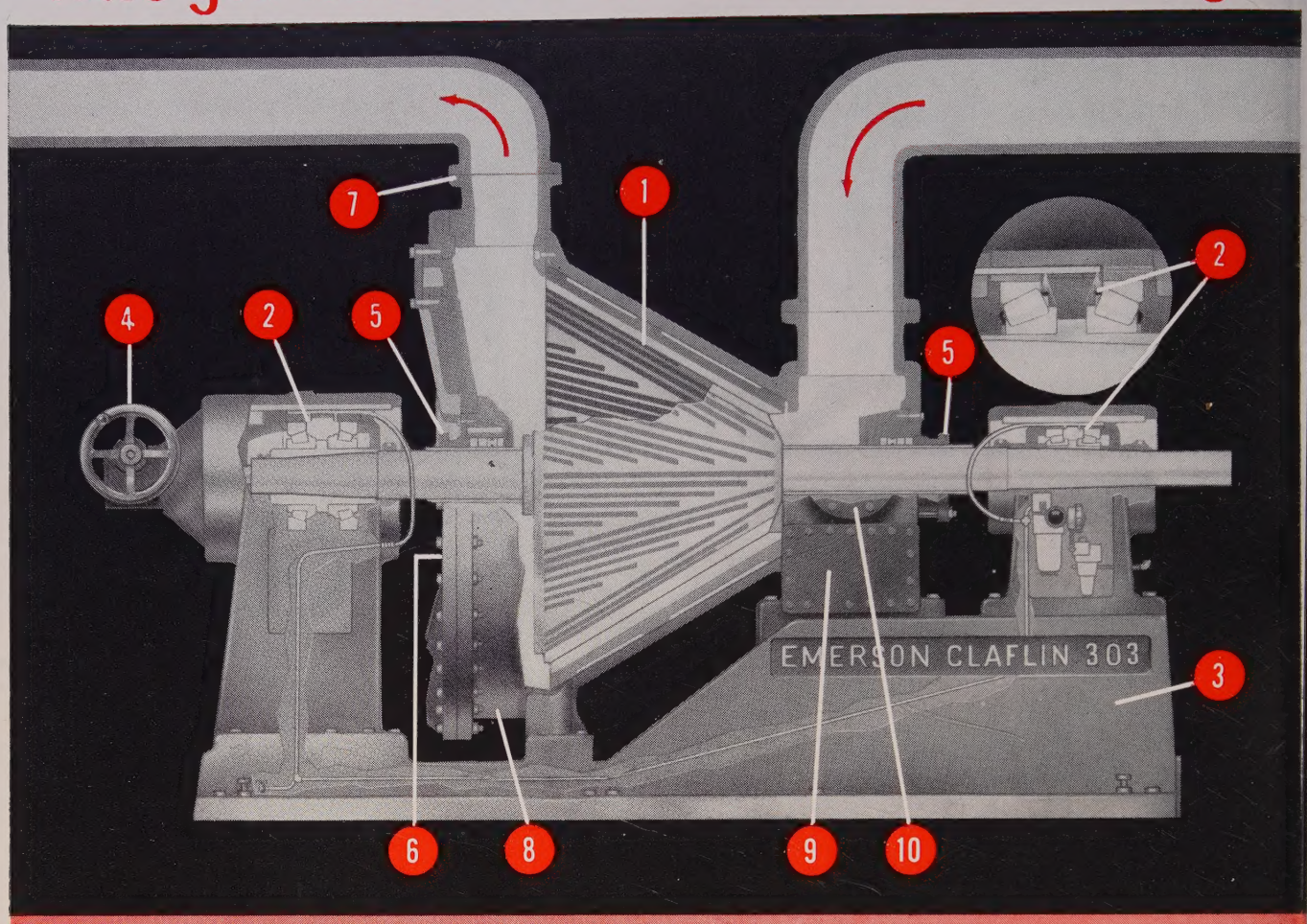
Tappi

E JOURNAL OF THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

JULY 1961

VOLUME 44 • NUMBER 7

Have you looked into an Emerson Claflin lately?



1. Wide tackle selection **2.** Oil mist lubrication **3.** Sturdy construction **4.** Micro-feed plug positioning **5.** Water-cooled packing boxes **6.** Large 2-piece head **7.** Stock outlet cast in shell **8.** Tangent cleanout **9.** Sand trap **10.** Hand hole

In stock preparation, no conical refiner can match the results obtained from the Emerson Claflin for several reasons. For example, a wide choice of tackle enables selection of just the right one to give you the desired physical results regardless of the furnish being run.

For high development — Develomax sectional or fabricated fillings
For rough stock refining — cast fillings
For defibering and refining — deflector type fillings
For controlled cutting and defibering — stainless steel fillings
For rejects — dam type or abrasive fillings
For maximum refining — lava fillings

Operating performance is another reason. Claflins are equipped with a built-in oil mist system of continuous, automatic lubrication, which feeds both double anti-friction roller bearings from a single reservoir. Constantly flowing oil mist keeps dirt out, conserves oil, eliminates lubrication downtime.

Sturdily built throughout, Claflins withstand up to 100 psi with virtually no vibration. Positive control over plug settings is held to .0005 inch by micro-feed handwheel adjustment. Coupling has full travel slide feature. One setting lasts the life of the filling. Water-cooled packing boxes protect against stock leakage.

Maintenance is simple. Large shell head is designed in two pieces for ease in changing fillings. Plug is removed without dismantling bearings. Stock outlet is cast as part of the shell, so mill piping need not be disturbed. Tangent cleanout is aligned to the direction of stock flow for quick and easy flushing. Sand trap and inspection hand hole are conveniently located at the stock inlet.

Widely recognized for its extreme versatility, the Emerson Claflin is proving daily its capabilities on an unlimited range of furnishes — screen rejects and fine papers, bag, wrap and multiwall, tissue and towel, corrugating, food and container board, boxboard and liner board, boxboard filler, roofing, hot stock and others.

Four sizes of Emerson Claflins cover an HP range of 5 to 500, RPM range of 350 to 1200 and tons per day range of 1 to 200.

For best refining, better look into the Emerson Claflin. Send for descriptive bulletin to The Emerson Manufacturing Co., Division of John W. Bolton & Sons, Inc., Lawrence, Massachusetts.

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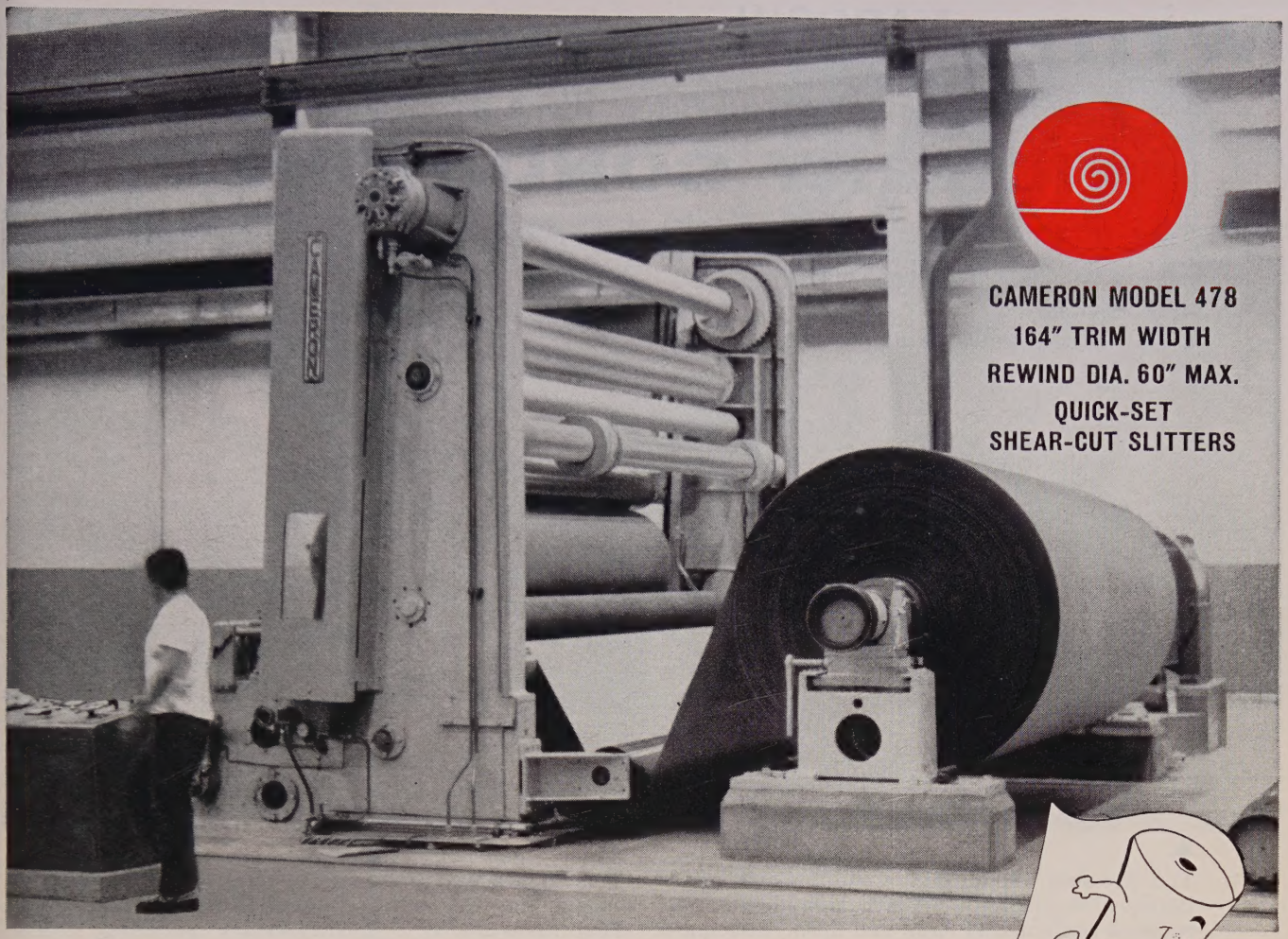

Georgia-Pacific *delivers* **The New Roll**

the superb running qualities of

One good reason why the Georgia-Pacific Paper Company has experienced such rapid growth as a kraft producer for West Coast and export markets is found in the superb running quality of the rolls shipped from the No. 2 machine at the company's Toledo, Oregon mill. Kraft papers and board up to 33 lb. basis weight are delivered in rolls made with extreme care to assure maximum trouble-free yield in high speed printing and converting operations. Also integrated roll control keeps the web *alive* for better end results, not stretched out *dead* in the rolls.

These fine Georgia-Pacific rolls are produced on a Cameron 478 unwinding-slitting-rewinding system, integrated and job-fitted by Cameron specialists for optimum unwind-to-rewind roll control. The heart of this Cameron 478 installation is a regenerative electrical unwind braking system which teams the main winder drive and an unwind braking generator under electronic amplifier controls to provide highly sensitive, continuous response to variations in web tension.

Among other roll control elements of the Cameron 478 are the isolated main drive gear box, down-pressure riding roll brakes, and cam-controlled, tapered automatic counterweighting. All roll control elements are adjustable to the characteristics of the paper or board to be run, the quality of the parent rolls, and the intended service of the finished rolls. The result is a fundamentally different kind of finished roll—a custom-made roll of superb running quality. We call it The New Roll.

Cameron specialists offer a unique test-run service to help you achieve the fine running qualities of The New Roll. In the Cameron Research & Development Service in Dover, N. J., test-runs are being made on all types of papers and board on integrated pilot systems which simulate actual job conditions. Here you can see, before you buy, either an improvement element, such as a new unwind brake and tension system, or a complete, integrated roll production system, engineered to give you The New Roll. Let's plan an early date for *your* test-runs. Write for details.

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AA-392

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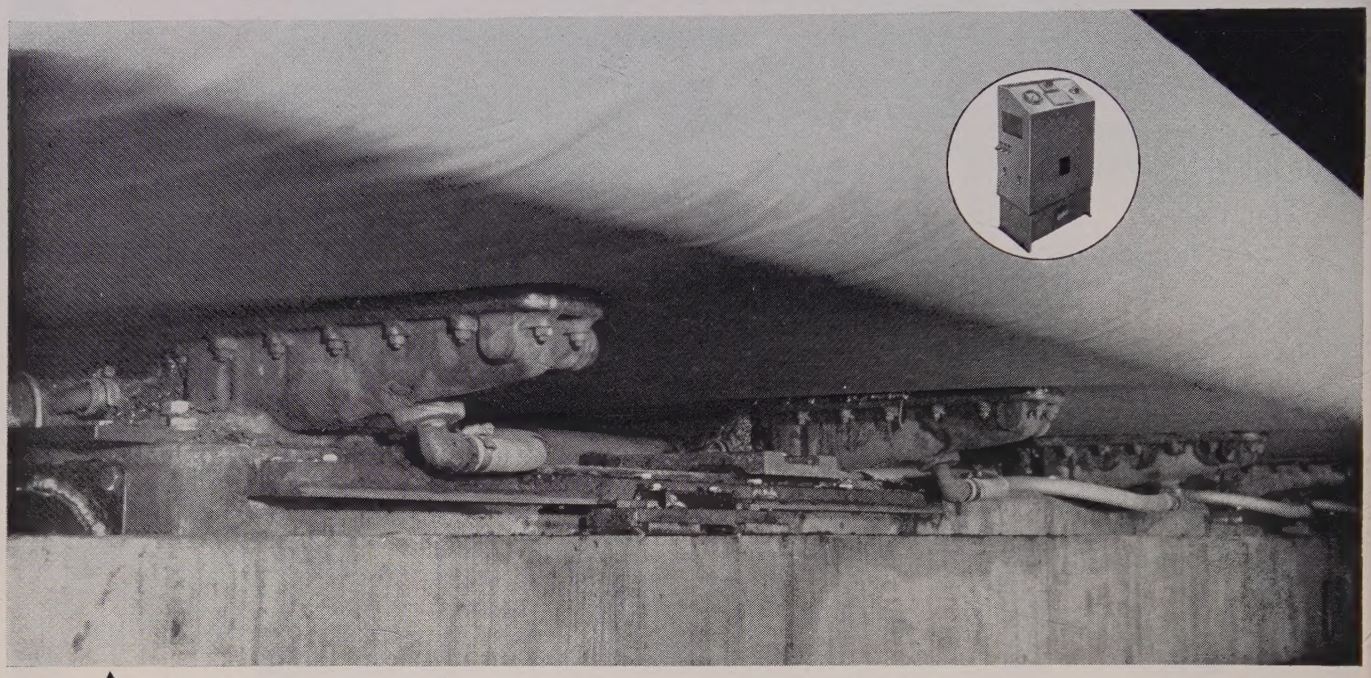
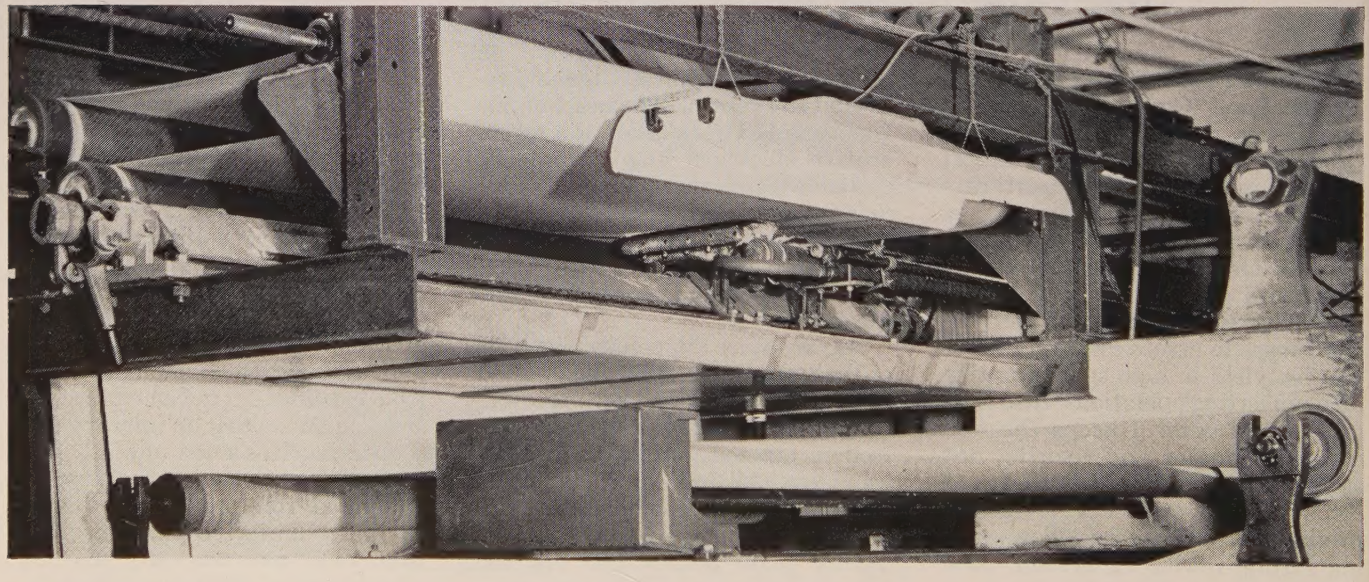


▲ This five-shoe Vickery Felt Conditioner is keeping one of the felts on a 234-inch, high speed board machine continuously clean and open. Inset pictures the control console that regulates the speed of the hydraulically driven Conditioner to match the speed of the felt.

This single-shoe Vickery Felt Conditioner is doing equally fine work on the second press of an 81-inch Fourdrinier making top quality writing specialties. It eliminates expensive shutdowns that used to occur two or three times a week. It keeps the felt uniformly clean and absorbent and it has succeeded in doubling felt life. ▼



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Edgewater Beach Hotel, Chicago, Ill.
Aug. 14–16, 1961

Twelfth Testing Conference
Queen Elizabeth Hotel, Montreal, Que.
Aug. 15–18, 1961

Eleventh Corrugated Containers Conference
St. Francis Hotel, San Francisco, Calif.
Sept. 6–8, 1961

Fourth International Mechanical Pulping Conference
(Tech. Sect., CPPA-TAPPI)
Edgewater Beach Hotel, Chicago, Ill.
Sept. 19–21, 1961

Sixth Deinking Conference
Hotel Harris, Kalamazoo, Mich.
Oct. 4–6, 1961

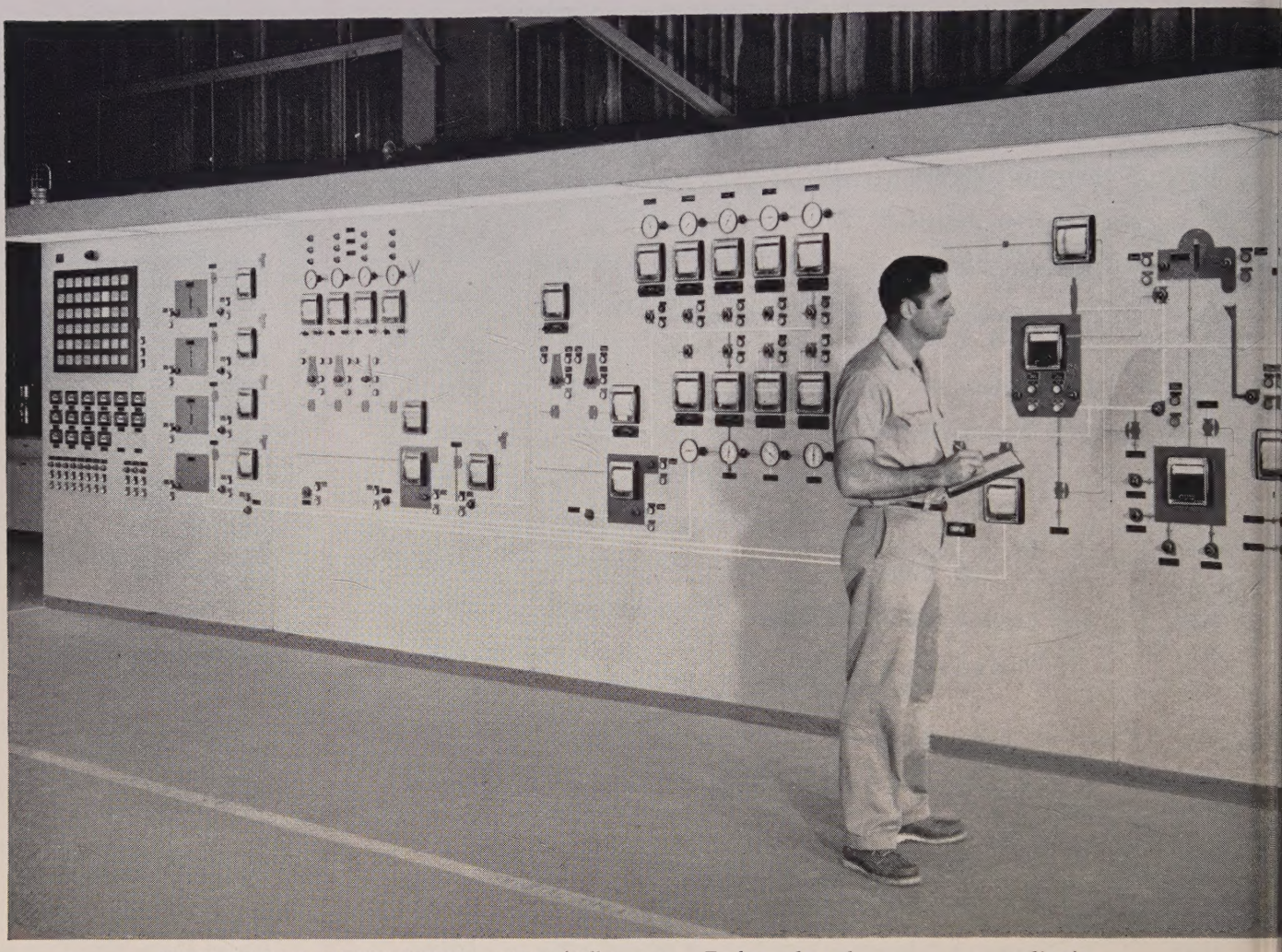
Sixteenth Plastics-Paper Conference
French Lick Sheraton Hotel,
French Lick, Ind.
Oct. 9–11, 1961

Sixteenth Engineering Conference
Shoreham Hotel, Washington, D. C.
Oct. 15–19, 1961

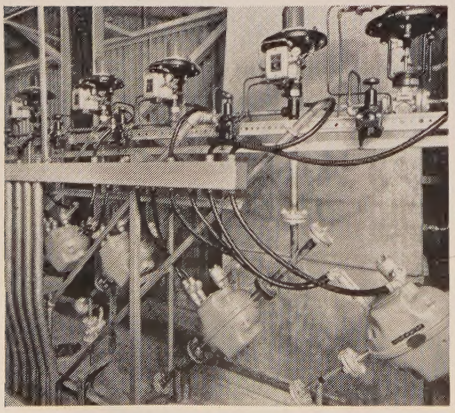
Fifteenth Alkaline Pulping Conference
Rice Hotel, Houston, Tex.
Nov. 1–3, 1961

Please refer to Local Section Activities for the locations and dates of Section Meetings

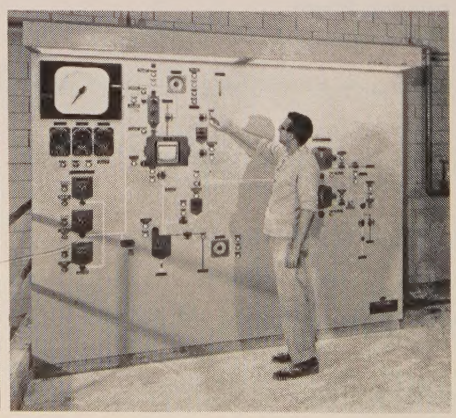
Marathon Southern Using on New Board Machine



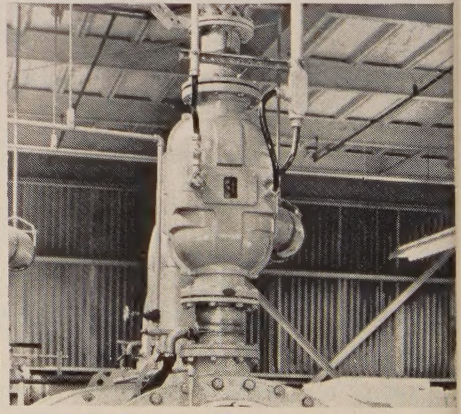
FOXBORO STOCK BLENDING PANEL automatically proportions 3 stocks, 2 dyes, and 10 different additives. Machine tender just sets dials and walks away. Foxboro does the rest — even readjusting flow rates to meet changes in machine demand, while holding proportions constant.



FOXBORO ½-inch and 1-inch Magnetic Flow Meters control flow of dyes and additives to various chests. Meters have no flow restrictions — never foul or plug up.

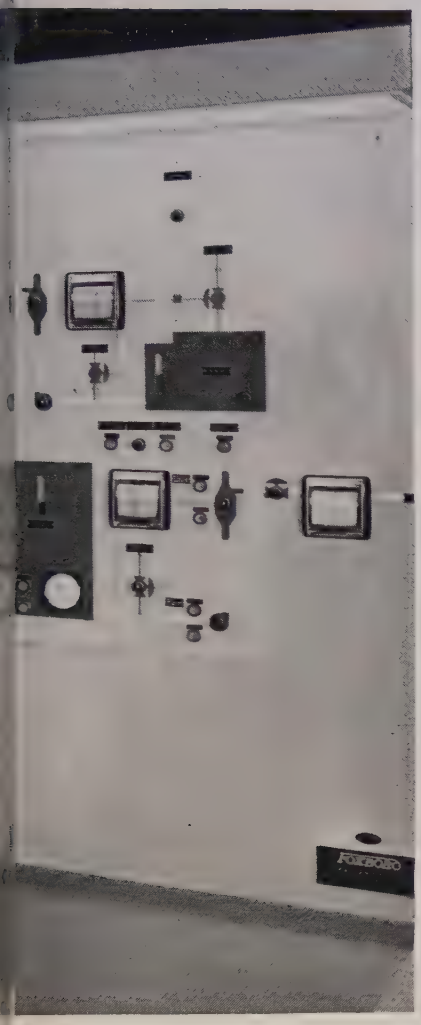


FOXBORO TRAILING-BLADE COATING MAKE-UP CONTROL PANEL automatically controls weighing, mixing, and blending of coating materials in accordance with pre-determined ratios.



8" FOXBORO MAGNETIC FLOW METERS keep continuous check of flow of stock from intermediate Claflin Refiners. If flow is excessive, warning lights on control panel attract operator's attention.

Foxboro Control at Naheola, Alabama



Foxboro engineering provides finger-tip control in new expansion project

Marathon Southern Corporation's new board machine is believed to be the most completely automated in the industry. Stock preparation, dry-end control, suction-box vacuum control, trailing-blade make-up, size press coating make-up — all are controlled by individual Foxboro graphic control panels throughout the mill.

The total instrument installation was designed to pay for itself in short order through precise control and reduction of production errors.

Complete mill, or single process, Foxboro instrumentation can help you make paper and board more efficiently, at lower cost. Ask your nearby Foxboro Field Engineer for details. The Foxboro Company, 787 Neponset Avenue, Foxboro, Massachusetts.

FOXBORO
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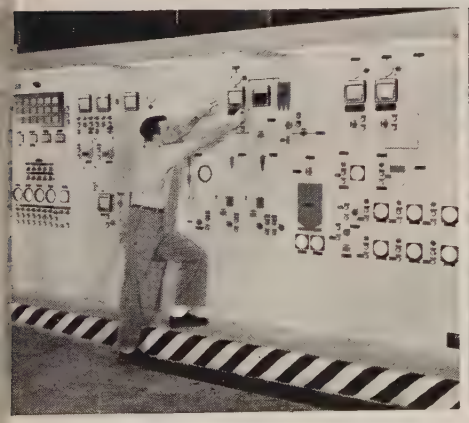
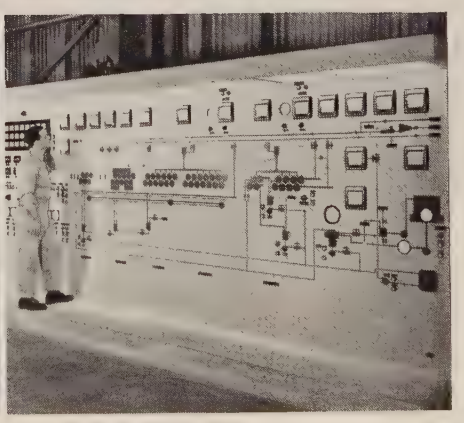


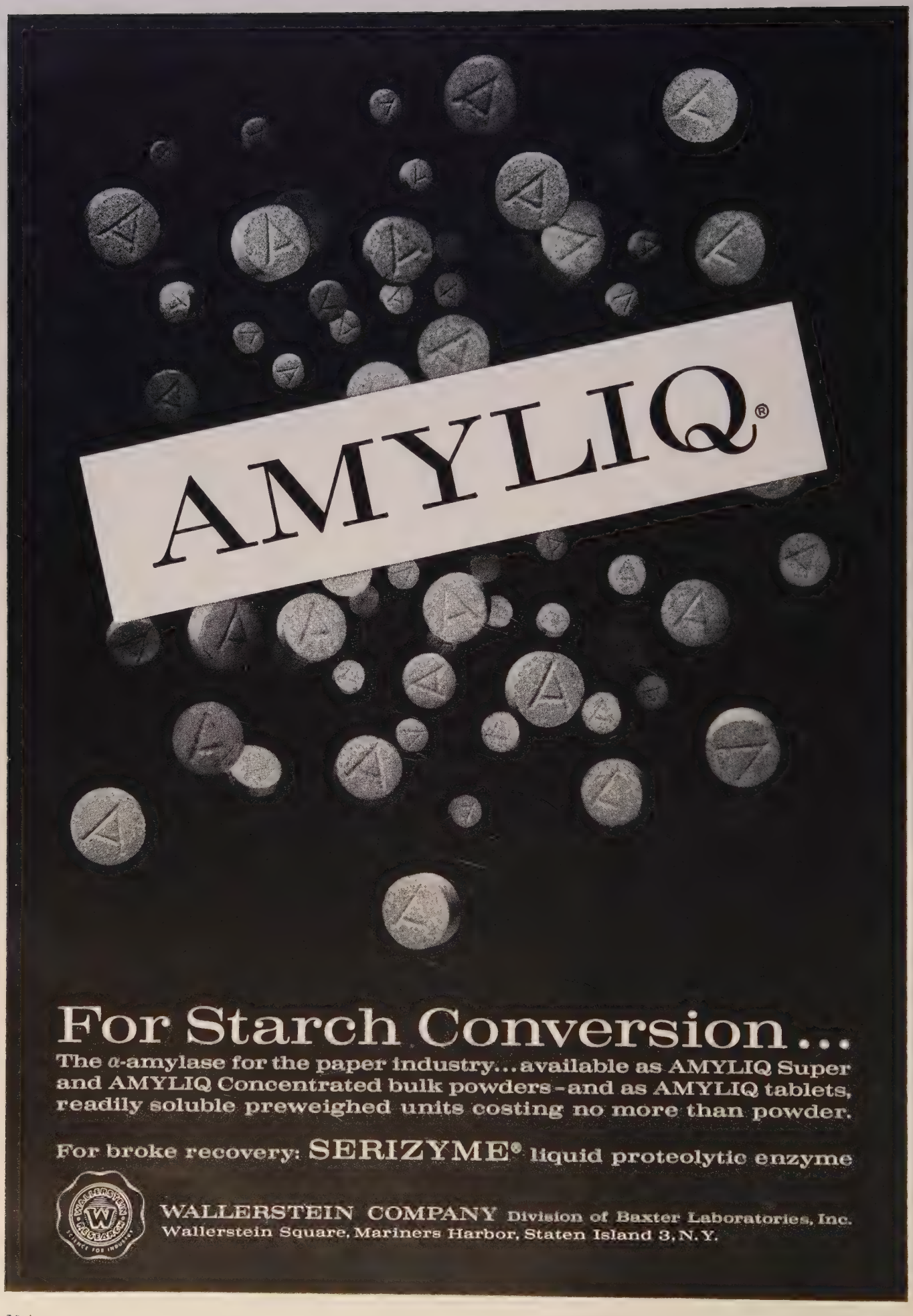
FOXBORO WET-END CONTROL PANEL. Small-case Consotrol* instruments, and graphic panel techniques were used throughout the mill. Marathon reports them a great benefit in training operating personnel.

**Reg. U.S Pat. Off.*

PAPER MACHINE CONSOLES provide operators finger-tip control over their mammoth board machine. Machine was designed and built by Black-Clawson Company. Start-up was smooth according to Marathon officials.



FOXBORO DRY-END CONTROL PANEL. All instrument systems were designed with Foxboro engineers, working in close cooperation with Marathon's contracting engineers, Rust Engineering of Pittsburgh.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Photograph taken with cooperation of The Sorg Paper Company, Middletown, Ohio, and American Tag Company, Chicago, Illinois.

They ended the "deadlocks"—cut labeling costs 52%—with CHEMIGUM LATEX!

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Lithographic Inks and Their Relationship to Paper

V. J. PORTH, JR. and L. F. ENGELHART

Litho inks were orginally founded upon linseed oil vehicles —but, by now, have become greatly changed. The lithographic principle, however, has remained unchanged and —though "offset" transfer has been adopted—plate-image reproduction is still based upon the repellency, or preferential wetting of oily ink and water. As a result, dampening and fountain solution remain inherrent to the process, and are frequent trouble makers in their influence upon ink-paper relationships. The ink characteristics and paper requirements needed to prevent, or minimize, such dampening and other troubles are outlined and discussed. Areas where paper and board can be improved are listed, and regions for most fruitful cooperation in ink-paper work are pointed out. Among the outlined future developments of litho inks are the important aspects of faster drying, and improvement of the "litho" properties of the softer web-fed inks needed for anticipated higher speed printing. It is expected that, new-type and better dampening, will greatly expedite such use and development in inks—and greatly improve general ink-paper relationships to the extent of markedly enhancing quality and productivity in both sheet and web-fed offset print'ng.

It has been said that "Good printing begins with the right paper" (*1*). This is particularly true in the case of lithography where acidified aqueous fountain solution, and dampening, are an inherent part of the process and any paper-ink printability relationship may be greatly influenced and complicated by this factor.

As you know, in lithography the printing and nonprinting areas of the plate are essentially in the same plane or level, and are so chemically treated that the image areas will accept ink and repel water -and the nonimage areas will do the reverse. Hence, lithography is sometimes referred to as a "chemical" printing process, and its successful application involves "surface chemistry" requisites in addition to the physical and mechanical aspects of the other printing processes. In the now universally used offset litho process, moisture or fountain solution always reaches (via the blanket) the nonprinted areas of the paper and also the printed or image areas—either by being entrained in the ink, or as a consequence of subsequent impression on the same or another press. Many times this moisture pickup from each color unit will add around 0.25% (of the weight of the sheet) to the original moisture content of the uprinted stock.

It is this acidified moisture (usually pH 4.0 to 5.0), with its potential of physical action, or chemical reaction, with the paper or some of its components, that may lead to such pressmen's headaches as pick, misregister, piling, inks scumming or tinting, roller stripping, dirty dampeners, and poor drying. Even in the absence of "wrong-way" reactions of such dampening system, it takes constant surveillance on the pressman's part to maintain the proper ink-water balance or equilibrium. Such necessary critical supervision is peculiar to the lithographic process, and stresses that the most important aspect of the litho operator's job is the problem of *keeping the sheets clean* during all stages of the production run. At the same time, it is this water, or dampening factor, that is mainly responsible for any needed changes or difference from letterpress to lithographic formulation in case of either ink or paper.

Less acid, less water and its better control, have been the aim in lithography for the past decade. Better inks, plates, dampening systems, and know-how, have recently given marked improvement in this respect—so much so—that it is presently not uncommon, particularly in web offset, for some lithographers to use regular letterpress stock, in grades ranging from news to machine coated, for certain lithographic printing. Despite this, as long as *any* water dampening is used in this process, there are certain safe-guard requisites that are needed in the formulation or composition of both papers and offset inks—or at least must be taken into consideration. Such precautions, or limitations, in relation to ink characteristics and paper requirements are stressed in the ensuing discussion, as they constitute extremely important factors in the establishment of most amicable litho ink and paper relationships. Similar consideration is likewise needed for litho inks formulated for their large and important application in metal decorating—and for printing on foil, film, and plastics—but, in this discussion, our subject confines us only to such ink dampening, and other relationships, that involve paper and board.

THE GENERAL STORY OF LITHOGRAPHIC INKS

As in the other graphic arts reproduction methods, development of litho inks and their related papers, has been hand-in-hand with the growth and improvement of their own particular printing process. Again, like in the other processes, and industry's growth in general, increased speed and productivity have been dominant in such growth and development of lithography. In such connection, the improvement in printing speed, alone, may not seem too impressive to the present layman familiar with space-age astronomical figures. However, to those of us in the graphic arts, the transition from Senefelder's "stone age," mere handful of single-color impressions per day, to our present many thousands of multicolor prints per hour, this increase seems to be quite an achievement.

Our point in mentioning this, to us, striking increment in printing speed, is that it reflects the drastic improvements and changes, in both ink-paper requisites and relationships, that have been needed to meet these high productivity demands. (Though not particularly relevant to our present topic, we cannot here resist acknowledging the modern papermakers'

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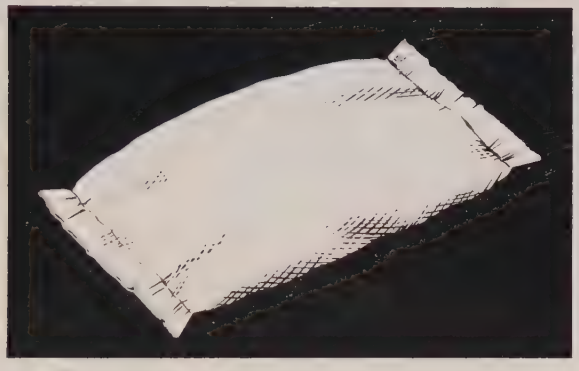

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Lithographic Inks and Their Relationship to Paper

V. J. PORTH, JR. and L. F. ENGELHART

Litho inks were orginally founded upon linseed oil vehicles —but, by now, have become greatly changed. The lithographic principle, however, has remained unchanged and —though "offset" transfer has been adopted—plate-image reproduction is still based upon the repellency, or preferential wetting of oily ink and water. As a result, dampening and fountain solution remain inherrent to the process, and are frequent trouble makers in their influence upon ink-paper relationships. The ink characteristics and paper requirements needed to prevent, or minimize, such dampening and other troubles are outlined and discussed. Areas where paper and board can be improved are listed, and regions for most fruitful cooperation in ink-paper work are pointed out. Among the outlined future developments of litho inks are the important aspects of faster drying, and improvement of the "litho" properties of the softer web-fed inks needed for anticipated higher speed printing. It is expected that, new-type and better dampening, will greatly expedite such use and development in inks—and greatly improve general ink-paper relationships to the extent of markedly enhancing quality and productivity in both sheet and web-fed offset printing.

IT HAS been said that "Good printing begins with the right paper" (*1*). This is particularly true in the case of lithography where acidified aqueous fountain solution, and dampening, are an inherent part of the process and any paper-ink printability relationship may be greatly influenced and complicated by this factor.

As you know, in lithography the printing and nonprinting areas of the plate are essentially in the same plane or level, and are so chemically treated that the image areas will accept ink and repel water—and the nonimage areas will do the reverse. Hence, lithography is sometimes referred to as a "chemical" printing process, and its successful application involves "surface chemistry" requisites in addition to the physical and mechanical aspects of the other printing processes. In the now universally used offset litho process, moisture or fountain solution always reaches (via the blanket) the nonprinted areas of the paper and also the printed or image areas—either by being entrained in the ink, or as a consequence of subsequent impression on the same or another press. Many times this moisture pickup from each color unit will add around 0.25% (of the weight of the sheet) to the original moisture content of the uprinted stock.

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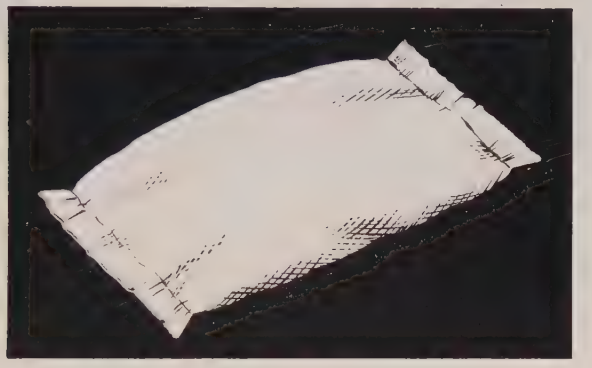

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similarly remarkable productivity achievements of being able to actually make their paper-webs at speeds, in lineal feet per minute, comparable to the fastest that present presses can print the finished product.)

The Inks Have Changed—But Not the Litho Principle

In inks, the two most basic changes that had to be made to meet this great printing speed increase were: (1) the ink consistencies had to be greatly "softened," and (2) their drying rates had to be very markedly increased.

The one basic property, or requisite, that could not be changed was their oily or hydrophobic nature and ability to resist solution or dispersion in aqueous or hydrophilic media. Ever since Senefelder's (1798) original "stone writing," the same principle of the mutual repulsion of hydrophobic and hydrophilic materials has governed the acceptance, or wetting, of ink in the proper plate image areas, and has continued as the fundamental "chemical principle" of lithography. However, though the original commercial litho inks were founded only upon linseed oil and carbon black, as things now stand, most of the wide range of raw materials and ingredients used in present letterpress inks can also be used, or converted to litho usage, by skilled formulators.

Such materials include most of the better pigments, resins, waxes, natural and synthetic oils, driers—and a more limited number of solvents. The solvent's choice is more limited than in letterpress for reason of possible deleterious action on litho offset blankets. This fact will be further discussed under Web-fed Heat-Set Inks.

As a result, practically any type of ink and nature of job within the past and present realm of letterpress can now be duplicated by offset lithography. It is usually a matter of equipment and economics as to which type of ink and process is selected in any given instance.

THE GENERAL CHARACTERISTICS AND REQUISITES COMMON TO ALL LITHO INKS

The Physical Characteristics of Litho Inks May Be Somewhat Similar to Letterpress

From a physical ink-paper relationship, lithographic inks, despite their usually necessary higher pigmentation and absence of surfactants, do not basically differ from letterpress inks. Practically any litho ink, by the proper consistency adjustment to the speed of printing and surface characteristics of the stock (such as pick resistance and absorbency), can be made to print satisfactorily by the letterpress process on most any letterpress paper and/or board. Such adjustment must follow an important, or even axiomatic, ink-paper relationship that applies to both litho and letterpress inks. This is, that as the peripheral speed of printing increases, the viscosity or tack of the given inks must be proportionally decreased—otherwise, paper pick, pulling from the grippers, or web break, etc., will follow.

In such conversion case, it will usually be found that the physical printability properties of the adjusted litho ink—such as tack, flow, length, and possibly penetration—will closely resemble, or even be identical with, those of the letterpress ink that was originally designed as best suited for the specific stock.

Conversely, some—but in this case, not all—letterpress inks, of suited consistency, can be run on lithographic equipment and stocks. A "physical" reason why there are some exceptions to this converse will follow—while the "chemical" reasons will be explained in subsequent discussion.

The "Offset" Litho Process Imposes Thin Film Restrictions—This Influences Strength and Gloss

A "physical" reason why some letterpress inks would not prove satisfactory, if run on present litho presses, is that, even though they did chemically lithograph or otherwise print satisfactorily, they would most times be too weak tinctorially, or color-wise, to match comparable printing with "true" litho inks on the same press.

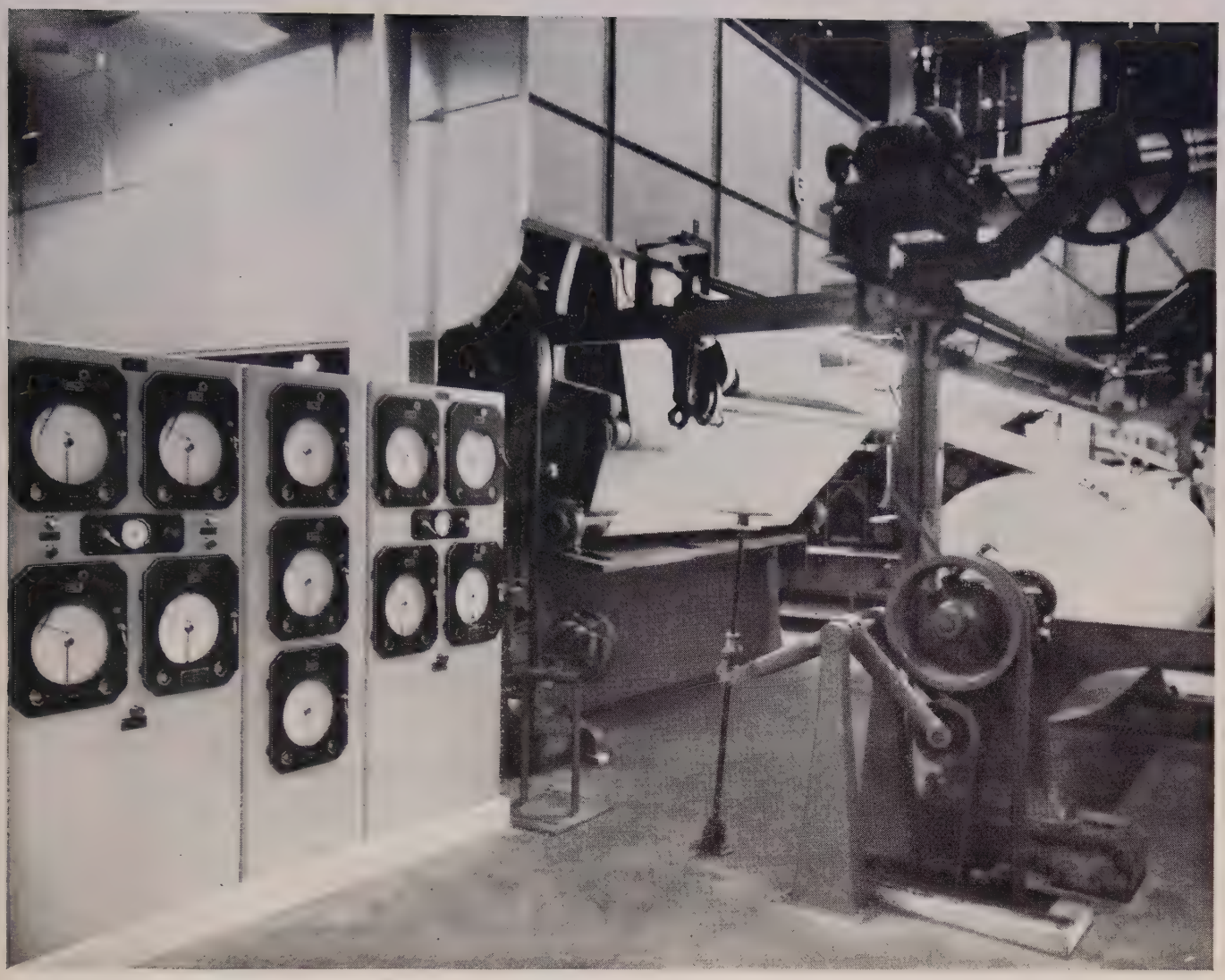
The explanation is that essentially all present litho production presses and inks are designed, or formulated, to print by the "offset" process. As the reader is probably aware, this is an indirect method of printing whereby the litho plate's inked image is impressed onto a blanketed cylinder, and from this resilient rubber blanket is transferred or "offseted" onto the material being printed. For reason of this "double" ink transfer (and, of course, planographic plates), the final film deposition is very thin, and is usually the order of only one half the thickness of comparable letterpress or typographic printing.

This, then, means that for the usual full-color work, a general requisite or characteristic of most present litho or offset inks is that they must be made very strong tinctorially, and loaded with as much strong "toner" pigments as consistency limitations allow. Offset's thinner film restrictions likewise present tougher "gloss" problems than with comparable letterpress inks. Ink film thickness and the stock's coating or surface "hold-out" go hand in hand with gloss; the thicker the film and the greater the hold-out, the higher the resultant golss.

"Dampening" Imposes Certain Chemical Requisites Not Needed in Letterpress

In addition, as mentioned in our introduction, the principal and most important distinction between the requisites of both litho inks and stocks from those of letterpress, is that the former must also withstand the influence and variables of the dampening, or "chemical," process that is an inherent part of the (present) litho process. This dampening mechanism must always supply a certain minimum of water, or acid fountain solution, to keep the plate nonimage areas clean. Anything contributing to, or necessitating changes, in certain narrow ranges of ink-water balance and pH, may tend to cause a multitude of troubles. From this viewpoint, neither ink nor paper should cause "conflict" or reaction with fountain solution and plate, or otherwise upset the rather critical physico-chemical equilibrium of keeping the image constant and the nonimage areas clean during all of the production run.

A general characteristic, or requisite, of all litho inks, therefore, is that they be made sufficiently oil or grease receptive and water repellent so as to accurately reproduce (in production multiples) the given plate image under correct press and dampening operation.



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More simply, they should be suited to the "chemistry" of the process and "lithograph" satisfactorily under the given conditions. From this, it is obvious that the ink and its color, or pigment, and vehicular components, *must not disperse or dissolve* in water or acid fountain solution—even when in intimate contact with same under the high-shear, rotational and pressure stresses of (present) rapidly moving rollers and plates—as in modern dampening and inking assemblies.

Additional Comments on the General Ink-Consistency Requisites of Litho Inks

As previously mentioned, the general rule is: the higher the peripheral printing speed, the more fluid and "softer," and less tacky or viscous, must be the given ink, Similarly, the lower the pick resistance of the stock, the softer must be the ink and the lower its tack. However, in the case of all litho inks, they cannot be made softer than "low viscosity tint" limits allow—as will later be discussed under "troubles." Not many years ago, all litho offset and direct litho were supplied in very "stiff or viscous bodies, so the pressman could variously reduce them to suit the job and stock at hand. However, present practice is for the ink maker to submit inks of closely regulated press-ready consistencies, and need for their adjustment in this respect is practically eliminated. Whatever, this above press-ready consistency may be, it is essential that it should not materially change under the given mechanics of the dampening application. More of what may happen if such change, as "flocculation" etc., will be covered in the following "wrong-way" reactions section.

WRONG-WAY LITHO REACTIONS AND ENSUING TROUBLES

Flocculation Troubles

Even though a litho ink be formulated so as not to disperse or dissolve in the fountain solution, it is almost inevitable that even the "best working inks will pick up and "entrain" a certain amount of such water in present-used dampening actions. This dampening solution entrainment normally gives a mechanically caused water-in-oil (ink) emulsion wherein the water "pickup" is usually of the order of 10 to 15% (of ink weight) in the plate and form roller distribution areas. This means that the ink (and/or its vehicle) carries some fountain solution finely dispersed in the "inside phase"—just as if it were added pigment. Under such conditions, the satisfactorily working ink preserves its original tack and most of its original length and flow thereby enabling it to function properly in the rheological aspects of the distribution, inking, and transfer operations of the process.

However, if the ink or emulsion is such that the entrained water is not maintained as separate globular entities, but coalesces with, and preferentially wets, the erstwhile oil-enveloped pigment particles, these particles adhere to one another—thereby "flocculating" or forming objectionable structure that builds up to a "high yield value" in the ink. Such "flocculated" or "water-logged" ink is manifested by a short, pasty, nonflowing or immobile body that gives faulty distribution and transfer. This is one of the banes of lithography, as it usually results in color loss, streaked printing, and ultimate "piling" on both plate and blanket. Improvement in inks due to new and superior wetting vehicles as well as better and lower gravity pigments, have minimized ink's contribution to such flocculation and consequent "piling." However, many present coated papers tend to instigate such objectionable action—with even the best of inks—for reason of such stock's deficiency in "wet pick resistance" under even normal (dampening) operation conditions. Such wet-pick shortcomings are further covered under "Specific Paper Requirements."

Tinting and Washing Troubles

Another, less frequent, but even more job-spoiling, possible variation of the foregoing, is where the ink, or some of it, "takes on" so much water that a "phase reversal" occurs, resulting in an ink or oil-in-water emulsion. Such ink, now with the water in the "outside" phase, breaks down, and spreads or disperses over all, or most of the plate, discolors the dampeners and, at times, may even cause "stripping" of the metal inking rollers. Such trouble cases, if mild, are usually called "tinting"—and, of more severe, result in what is referred to as "washing."

Greasing May Be Another Litho Trouble

The third, and last, of the strictly "chemical," fundamental lithographic troubles that may be directly related to ink performance is called "greasing." This trouble is evidenced by the formation of ink-receptive dots, points, or image extensions in the supposedly non-image areas of the plate and print. The usual visual result gives a "dirty" sheet, or print, that frequently resembles certain cases of tinting. It usually differs, however, in that greasing is ordinarily not overall, uniform disfigurement, but is generally confined to restricted regions—such as near the gripper edges, or following large image areas, and plugging up in fine reverse type. Greasing further differs from tinting in that, if not caught and rectified in its initial stages, it will usually do permanent injury or damage to the litho plate.

Fundamentally, "true" greasing is due to migration of "greasy" polar-nonpolar surface active agents (such as the fatty acids) to certain nonwork areas where they penetrate, and replace, the plate's original ink repellent gum-plate or other hydrophilic complex. Upon such migration and penetration, these dangerous surfactants molecularly "bond" and "orient" at the plate interface, so that their tip surface areas are henceforth ink receptive and water repellent—just as if they were small scale plate images. Press operators sometimes endeavor to remedy "greasing" (whatever its cause) by increasing the "acid" in their fountain solution. While such pH lowering of the dampening system may temporarily help to "desensitize" greasy or dirty non-image areas, it is fraught with dangers in other respects. Such dangers could entail "sharpening"—or even "blinding"—plate image areas, ink "stripping" of the metal rollers, and distinct detriment to the drying and binding properties of oxidizing-oil inks.

Greasing versus Low Viscosity Tint

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distinguish from what is called "low viscosity tint." The principal reason for the occurrence of this latter phenomenon is physical or mechanical, not chemical—and is due to the ink not having sufficient viscosity or internal cohesiveness to withstand the mechanical attrition of the dampening (and sometimes ink) rollers passing over and across the various areas of the plate.

Even the best of present litho inks will so break away and disperse (as tiny globules) over the nonimage plate areas, if their viscosity, or tack, is reduced below a certain minimum that may vary under different application conditions. Present improvement in plates, dampening mechanisms and water control, is permitting the use of "softer," less viscous inks that are much less vulnerable to such "mechanical" tinting—and are even proof to "chemical" greasing. However, present paper deficiencies (to be discussed later) still prevent ink from being made as soft, or low in tack, as would be occasionally desirable. This particularly applies in higher speed web-offset printing.

Flocculation and tinting ordinarily do not ink-sensitize the plate's nonimage areas as does greasing. Hence, as previously mentioned, such troubles are not so prone to end up with permanent injury to the plate as in the case of persistent or bad greasing. Incidentally, such "bad" greasing is frequently called "scumming." When things are in this latter sad state, the dampening rollers usually become so dirty, through back-way ink pick up, that they cumulatively add to the objectionable appearance of the print and increase potential printing wastage.

The Paper's Influence, or Responsibility, for Causing These Litho Troubles

In the aforementioned troubles, the influence of paper and board may be an added factor, or variable, that through initial paper-fountain solution reaction may, in turn result, in promoting the same, or similar, "wrong-way" ink-fountain solution actions and consequent troubles. Hence, we have led up to an indirect ink-paper relationship that is objectionable and peculiar to lithography. Unfortunately, this influence is not ordinarily easily or accurately predictable by laboratory tests or techniques—and usually needs confirmation of such tests by long-run press trial.

Surface Active Agents May Be Trouble Sources

The foregoing examples of possible greasing, flocculation, and tinting through adverse wetting, bonding, and/or emulsification are, for the most part, fundamentally caused by the forces and activities within the physico-chemical realm of "surface chemistry."

Other than cases of "scumming" caused by extractable alkali from paper coatings in amounts sufficient to ink-sensitize, or dirty, the plate nonimage areas—most wrong-way litho reactions (and particularly those of flocculation and tinting), can be caused by minute quantities, or even traces, of surface active chemicals. Such would be the small amounts of surfactants, or wetting agents, that might be leached from, or formed by, dampening solution action on certain papers or their coatings. Typical of such dangerous contaminants would be traces of surfactants similar to laundry-type soaps or detergents, which could literally "wash off" the image-ink on many present litho plates.

Through sad experience, ink formulators, plate makers, and fountain solution suppliers, have learned to guard against inclusion, or contamination with, such wrong-way surface active agents and chemicals in their respective products. It is hoped papermakers are similarly cautious for best ink-paper relationships in the litho process.

THE CHARACTERISTICS OF THE VARIOUS TYPES OF LITHO INKS

The "Offset" Process Dominates Present Lithography

First, as previously mentioned, it is to be remembered that present commercial lithography is confined almost exclusively to the "offset" process. Originally developed in the early 1900's for metal decorating, it was subsequently found that the offset transfer from a resilient blanket enabled the finest of halftone and line work to be faithfully reproduced on even the roughest of paper, board, or other surfaces. Such "indirect printing" continues, to this day, to be one of the particular advantages of the process—as, in addition to the foregoing, it minimizes impressional squeeze, make-ready, and set-off—enhances smooth, uniform complete-coverage ink lay, helps drying (due to thin films), and protects its plates from undue wear. Another structural advantage in two-side web printing press design, is that it permits blanket-to-blanket cylinder assembly, thereby eliminating impressional cylinders—thus saving press cost, weight, space, web-lead, and so on.

Despite the fact the above advantages of offset are so important as to outweigh any disadvantages and merit its almost universal litho adoption, there are quite a few shortcomings to this process. From a general viewpoint, these disadvantages are principally: its thin-film application—slurs, creep, or dot and fine-line distortion under excessive blanket squeeze—and its overall contact (nonimage as well as images areas), in the blanket's impressional nip. From our particular ink-paper relationship viewpoint, other important disadvantages are that of having added rubber blanket areas in which ink may be exposed to evaporative and/or absorptive "tack-up," skinning or drying—and, a moist blanket surface onto which paper-coating pigment, or fiber, may adhere and accumulate during the periods of the production "run."

The above respective merits and shortcomings of litho offset have been mentioned, at this point, and rather at length, as they are related to the types of inks, kinds of surfaces, or classes of work, in which this process may, or may not, have found most advantageous use in competition with other printing methods.

The Various Ways of Classifying Ink Types

From a formulative as well as application viewpoint, offset litho inks are usually first divided into the two broad divisions of: (1) metal decorating inks, and (2) all other offset inks. In the "all other. . . ," or second, of these divisions, offset inks for paper and/or board constitute by far the present largest portion or class. This, naturally, is the class our topic covers. These paper and board inks—furthermore, like in other processes, can be, and frequently are, subclassified or "typed" from a variety of viewpoints—such as from: kind of press used, composition of the ink, drying

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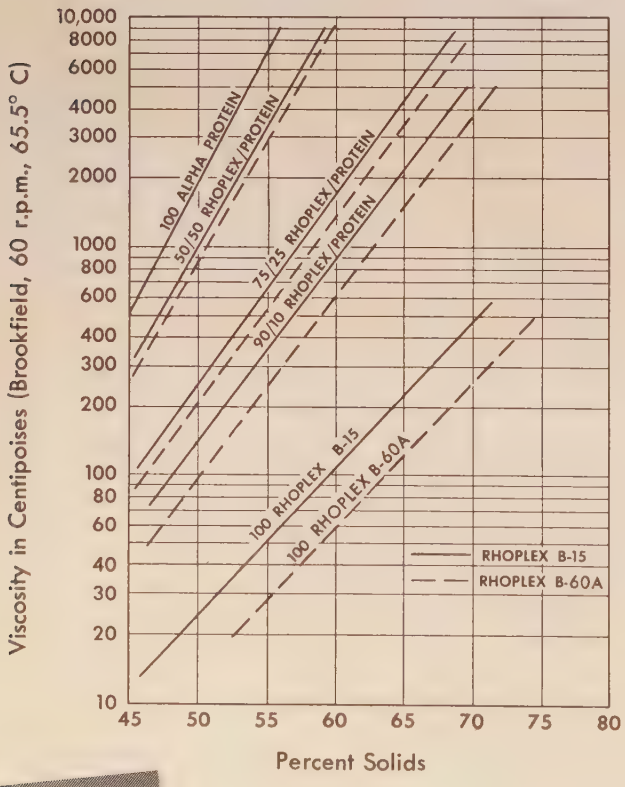
Viscosity—RHOPLEX coatings containing up to 60 percent solids can be handled readily at high speeds, provided the binder content is mainly RHOPLEX. Figure I shows effect of RHOPLEX on viscosity.

Figure I



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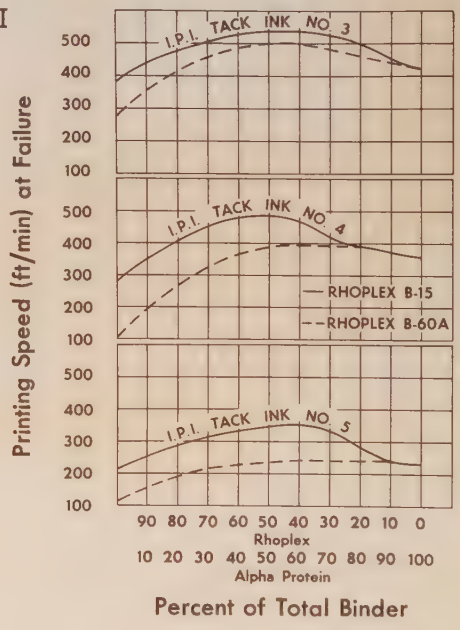
Printing Quality—RHOPLEX imparts to paper a smooth, well-bound surface, exhibiting good ink receptivity and good ink holdout. These properties, in turn, contribute substantially to printing quality. Excellent color fidelity, brilliance, and printing definition are typical of printing performance on coatings bound with RHOPLEX. Pigmented coatings show a very high degree of color stability, characteristic of all RHOPLEX acrylic materials. Figure II shows effect of RHOPLEX on I.G.T. pick resistance at 16% total binder on pigment (clay-titanium dioxide, 80:20).

Figure II



Brightness and Gloss—RHOPLEX preserves the high brightness inherent in pigmented coatings. It also produces higher gloss than is possible with natural binders. Unlike natural materials, RHOPLEX is a thermoplastic, has a flow and leveling action under the heat and pressure of the calender rolls.

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methods employed, character of paper or board printed, nature of the printed product—and so on.

Inks Can Be Best "Typed" by Their Vehicular Composition (and Consistency)

In most cases, it is the variation and nature of the vehicular composition, and the final press-ready ink consistency, that determines the suitability of *any kind* of ink to a given process, method and rate of drying, type and speed of press—and proper relationship to any to-be-printed surface. This "vehicular variation" likewise determines the after-printed and end-usage appropriateness for any particular job—but in this instance, also shares suitability in combination with whatever pigments are likewise used. On the other hand, you can usually bank on there being but little basic variation in color pigmentation (though extender pigments may vary) on a given or specific color-job—whether that job be printed by any of the three different printing methods of processes.

From this, you can see that vehicular composition and its variation is far more important in ink differentiation than is pigmentation, and that we can usually ignore the latter, and merely give vehicular nature and ink consistency as sufficiently descriptive of the various types of ink and their relationship to paper and board.

We do this in the following descriptions:

Sheet-fed Litho Offset Inks for Paper. The vehicles of these inks have been mostly changed from straight oils to oleoresinous and/or long-oil alkyd varnishes—together with water-insoluble drier, usually cobalt, that may vary in amounts according to the oxidation propensities (if any) of the pigmentation, paper stock, and desired dry-time results. High-boiling, low-solvency solvents (usually of petroleum origin) are sometimes included in order to lower viscosity and tack, and to obtain evaporative "set" on nonabsorptive or hard-sized stock—and to get this and added penetration on the more absorbent papers. Sometimes, gel and/or waxy compounds are likewise included to improve "working properties," enhance hold-out or gloss, minimize set-off, and add "slip" to the dry film. In the above, the afore-specified high-strength "litho" pigments are meticulously dispersed, in percentages usually appreciably higher than in comparable inks of other printing processes—and this for reason of the thin film application limitations in offset.

Such inks, next to those of metal decorating, usually have the most viscous press-ready consistencies of all other large-used normal printing inks types or classes. These consistencies may somewhat vary, in their own class, depending upon printed speed and the pick-resistance of the paper. This usual range may spread from around 15.0 to 25.0 readings on the LTF Inkometer, at 1200 r.p.m. and 90°F. (*2*).

The final or completely oxidized drying (as in a pile at room temperature) of these inks is usually a matter of hours, to overnight, depending upon formulation, stock and other printing variables. Other immediate after-printed problems concerning these inks and their papers—such as set-off, smudge, and sticking in the delivery stack—are usually fewer and less troublesome than in comparable letterpress printing. The main reason for this is because of offset's thinner films, smoother and more uniform ink lay, and absence of ink "beading" at type and image edges. However, to prevent such set-off and possible sticking trouble—as in the case of gloss inks, multicolor superimposition, and low absorbency paper—either "wet" or "dry" antioffset spray is frequently used at the delivery end of the press.

Further Subclassification of Sheet-fed Offset Paper Inks. These paper sheet-fed inks and formulations may be further subclassified into the important categories of publication, packaging, and commercial or job printing. In turn, each of these subdivisions may have or need specific paper-ink relationships and functional or end usage requirements, depending upon the kind of printed product. Typical examples would be: magazine and book inserts and covers, bags, wraps, labels, posters, calenders, greeting cards, certificates, mail-inserts, and business forms.

Probably a wider variance in the selection or balance of our mentioned vehicular ingredients, would be that involved in the formulation of the comparatively recently developed high-gloss, quick-set, sheet-fed offset inks. These special inks require the highest ratio of specific gloss-resin varnishes and solvents—and get their quickest "set" by "selective" vehicular penetration, or filtration, on special porosity coatings, as will be late discussed under specific paper-ink relationships.

Sheet-fed Offset Inks for Board. In the sheet-fed paperboard field, offset lithography has shown exceptionally great recent growth—as it has entered into many segments of the carton printing industry. For such carton printing, offset inks had to be improved over normal paper inks so as to have the highest order of gloss, binding, rub resistance, and product proofness to the given carton contents. As a result, such inks will usually have a generous amount of "slip" compound and drier, and contain a maximum of high-grade, hard-binding, gloss oleoresinous varnishes. Here, too, quick setting and absence of "set-off," upon high-speed heavy-weight pile delivery, are necessary requisites—and full advantage must be taken of any preferential absorptive and evaporative "set" that ink-board relationship can furnish.

Aside from the inks, with cartons the first evident advantages of offset seem to be its ability to give superior quality illustration and detail (such as with half-tone screens finer than 100 and up to 200-line screen), and its faculty to do this even on the rougher boards, and its being able to show less quality variation from sheet-to-sheet as the given boards necessarily vary in caliper, surface smoothness, and uniformity. Of course, cheaper and faster made plates, one-piece plates up to huge 58 × 78 in. sizes, quick handling of combination line and halftone copy, as well as less makeready—and frequently higher (versus flat-bed) printing speeds—are other important offset advantages.

Web-fed Litho Offset Inks. The trend to web-printing in all major reproduction processes has long been evident; it potentialities of high speed, multiple operations, and automation, are particularly suited to modern productivity requirements. In this country, web-feeding has always dominated gravure and flexographic printing—and is presently a major part of letterpress. Web printing got a slow start in offset, and is

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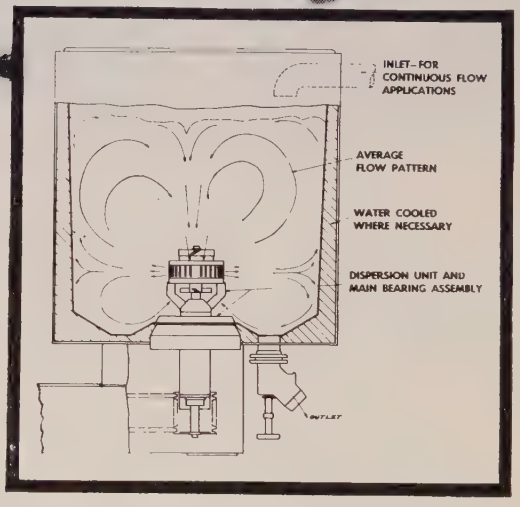

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still a minor part of total litho production. However, its upward trend is likewise even more strikingly evident—particularly, since web-offset's present reproduction quality, speed, and economics, compares favorably with any other printing process.

The bulk of the present inks in this class are of the heat-set type used for paper printing in the publication field—though some of the more recently installed smaller web presses (some without heaters) are being used for commercial work. Basically, these inks are not dissimilar to most heat-set letterpress inks—with the proviso, that the former's pigment-vehicle components, and combinations, satisfactorily lithograph. In compositon, they roughly average about one third each, by weight, of pigment, binder, and solvent. The binder component usually consists predominantly of high-melting, quick solvent release, synthetic resins, which may be permissibly plasticized with oxidizing or other oils, if the printing forms are "light" or the stock has a moderate degree of absorbency. The solvent portion usually consists of blends of "wide-cut" low-solvency, petroleum hydrocarbons of sufficiently high boiling range to be essentially non-evaporative on rollers and blanket—yet volatile enough to split-second leave the ink film at web temperatures around 250 to 350°F. These solvents presently have to be of relatively low solvency to prevent absorption by, and possible other objectionable action upon, offset rubber blankets. Even though the presently used "buna" and other synthetic elastomers are far more solvent resistant than the original "natural" rubbers, they still need improvement in this respect to give more latitude in such heat-set offset formulation.

In printing consistency, these inks generally must be distinctly "softer," or more fluid and less tacky, than sheet-fed offset inks. With such soft inks, the formulative problem is to give them such low viscosity without inducing "low viscosity tint" and promoting "greasing." Their consistency ranges from some 6.0 to 20.0 Inkometer reading (at 1200 r.p.m. and 90°F.), depending upon the surface characteristics of the stock and other printing variables (*2*).

There are cases with these web-fed inks—such as with weekly newspapers, tabloid sized brochures, certain telephone books, pattern and cheap catalog printing—wherein the forms are "light" (small coverage) and the stocks very absorbent, that inks that dry by penetration, some evaporation and/or oxidation at room temperature, are used. Since, news stock, itself, or similar uncoated high groundwood papers of highest absorbency, are almost always used—the inks, and their vehicles, must be a fluid and low in viscosity as the softest of the "heat-sets"—so that they dry and set for the most part by penetration, and print without giving "pick" or "fiber-lift" on these weak surfaced papers.

SPECIFIC PAPER REQUIREMENTS FOR BEST LITHO INK RELATIONSHIPS

Under the above heading it is sometimes difficult to differentiate between what should be a paper's specific requirements for best ink relationship—or its general requirements for best performance with the lithographic process, itself. As a result, our following listing of "specific" requirements for such best relationship may not cover all aspects of their relatedness. However, we think they include those requirements which are generally considered to be most specific—even though some (as noted) may only apply to sheet printing, while web and heat-set applications may additionally require some or all of the other "specifics" that are herein listed. On this basis our listing consists of:

Relatively High "Damp" or "Wet-Pick" Resistance Is a First Requisite

The higher such "wet pick resistance," the higher the permissible tack or viscosity of the ink. This relatively high tack is necessary in present litho inks for: maximum gloss, sharpest printing, clean sheets, and the "snap" erstwhile only associated with letterpress. Likewise, the greater the pick resistivity, the faster can be the printing speed without causing a whole family of "pick troubles," involving: piling, frequent washups, shortening plate life, and generally lowering the print quality and productivity.

Lack of "damp" or "wet pick resistance" sufficient to ultimately lead to serious "piling" on plate and blanket, seems to be a particularly prevalent shortcoming of such coated stocks as are presently being used in web-offset printing. Here, the latter's high peripheral speed adds additional "pull" to the moisture-weakened coating, causing some of its pigment particles to transfer and adhere to plate and blanket—thereby forming a nucleus for cumulative build-up of either or both, coating and ink pigment. Oehme and Nepper (*3*) in their recent paper describing their

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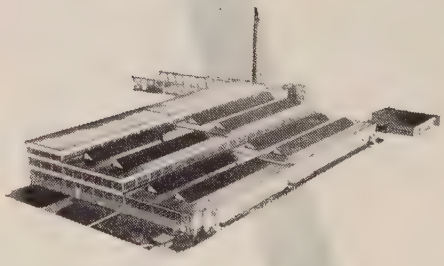

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measurement of the "piling propensities" of offset coated papers, evidently agree with us when they state, "We think the wet pick resistance property of paper is the most important one to control in the reduction of piling as influenced by paper under normal lithographic proces conditions."

From the above, it is obvious that in any pick test for lithography, it is imperative such test accurately simulate the printing impressional contact with "moist" blanket and thin-film ink on same.

Freedom from Fountain Solution Extractives or Reactants

There should be absence of any materials, or chemicals, that might be soluble in, or chemically react with, fountain solution and result in contamination or "conflict" with its functions—thereby causing "wrong-way" action on the plate, or in the water balance, during printing. As example, the presence of extractable surfactants might cause ink greasing, tinting, and emulsification—or reaction with the fountain solution acids resulting in change of dampening pH, formation of soaps, plate deposits, and dissipation or loss of the ink's drier.

It has taken many years of educational endeavor to get lithographers to decrease their dampening acid to the present used (4.0 to 5.0) pH range. Any extractive and/or reactive components of a litho stock that may appreciably change (or even buffer) such pH equilibrium, are likewise apt to give similar trouble to those just cited.

Good In itial Ink Receptivity and Transfer

Ink "receptivity" has been defined as the ability of a surface to accept the transfer of ink and to retain a uniform film on such surface (*4*). Such property is probably dependent upon the "wettability" of the paper (surface) by the ink and the initial rate of absorption of it, or its vehicle, at the instant of impressional contact and transfer. In other words, the paper should have such properties, that offset ink transfers readily and uniformly onto it—and, we hope, does so in a manner to give facsimile reproduction of the image and all its detail as furnished on the plate and blanket. For satisfactory results in any printing process, it is a requisite that the stock have good "receptivity" for the given inks. In lithography, litho papers and boards may occasionally be surface sized, or otherwise treated for water repellency, in such a manner as to interfere with proper ink "take" or receptivity, thereby resulting in poor transfer as well as possible detriment to both ink drying and binding.

Ink Hold-out or Absorbency to Be Controlled, Dependent Upon Usage

The initial, and ultimate, absorption characteristics of paper and board will, and should, depend upon the printing variables and end usage of the printing. High gloss is a usual requisite for labels, coated paper publications, and coated board for cartons. Matte, or dull finish, is usually expected for calendars, artwork, maps, book text, and most uncoated stocks—particularly, if they approach the quality of newsprint.

Naturally, a high order of ink "hold-out" is a requisite for gloss. However, in sheet-fed offset printing some absorbency must ordinarily be left in the stock—otherwise, even the best of spray equipment cannot always prevent setoff or sticking. On the other hand, heat-set web-printing needs essentially no absorbancy—as is exemplified by such method's successful printing on metal foils.

Another example where a "specified" order of absorbency is required, is that on coated papers and boards for use with the newer (and usually air drying) quick-set gloss offset inks. Such inks obtain their exceedingly fast initial set (frequently a matter of a minute or so) for reason of selective penetration of parts of their vehicle. Such preferential absorption, on the stock's part, seems dependent upon a certain surface pore size range in their coatings. If the coating's porosity is greater than this range, much of both quick-set and gloss are lost; if the pore or interstice openings are smaller, gloss is retained—but then, the quick setting disappears.

Examples of variable hold-out, such as in the above, show the necessity for having various absorbency ranges in different stocks, depending upon their usage; and they illustrate the need for such ranges being paper mill controlled, or uniformly maintained, in any given usage.

The foregoing four specific requirements are those usually needed for all offset papers and boards—which includes those for both sheet and web-fed printing. However, the latter, or web-printing, may additionally require three more specific litho stock requirements. These are:

Comparatively High Tensile Strength—for Web-Offset Printing

Offset stocks usually have to be stronger than comparable letterpress webs in the captioned respect, in order to withstand the additional "stick" and "pull" in the nip of the damp and inked blanket under high linear speeds.

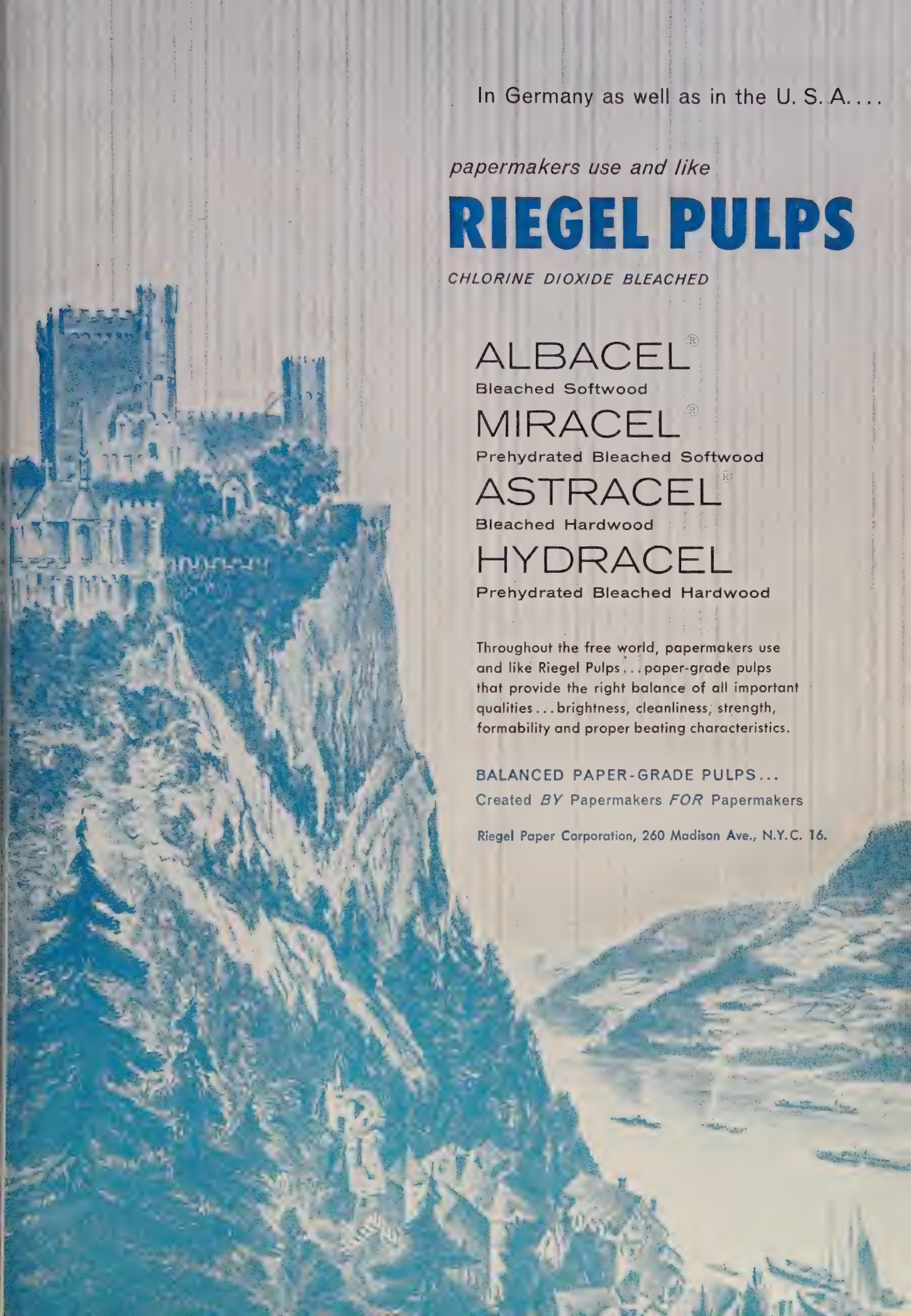
In addition to the above needed high tensile strength, heat-set web-printing imposes two added requirements for reason of its inherent heat-drying conditions.

These are:

Nonblistering under Heat-dry Web-printing Conditions. This particularly applies to coated web-offset papers whereon a "tight" two-sided coating may trap moisture that is volatilized under the given heating conditions. In this type of printing, the web temperatures may range from 250 to 350°F. depending upon the printing conditions. Sometimes, exceptionally high moisture content of the coated web, as around 7.0% or more, may promote such "blistering."

Nonscorching under Heat-dry Web-printing Conditions. Coated papers and boards are usually free from scorch or heat discoloration tendencies (in the 250 to 350°F. range) due to protection by their surface-coat pigment. On the other hand, uncoated stocks are not so protected and, hence, may be vulnerable to cellulosic and/or sizing heat-discoloration, under high temperature drying conditions.

The foregoing, then, constitute what seem to be the specific paper requisites that are usually most directly connected with litho inks in relationship for their best combination and printability. Of course, as previously mentioned, there are quite a few more paper characteristics that, though less specific or direct in



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their influence upon ink performance—do affect or influence the ink's performance as to printability results and the quality appearance of the finished job.

The more important of these less specific requirements follow:

Some "Less Specific" Paper Requirements for Good Litho Ink Relationship

Surface Smoothness. This is probably the first paper characteristic or requirement that appears to be missing from the preceding—as it is usually listed as the first requisite for best letterpress and gravure printability. However, offset printers usually brag that such "smoothness" isn't necessary—and that they can print even fine detail on the roughest of stocks and materials. Even so, when offset was originally confined to rough textured uncoated stocks, its consequent diffuse reflection and softness of tone was thought of as being necessarily characteristic of the process—and it could not match the "snap" of relief printing on coated stocks. Nevertheless, when "smooth" coated papers became available for offset—then, for the first time, this process (and its inks) could match such uniform gloss, color purity and sparkle, as had previously been monopolized letterpress. Hence, for certain particular usages, we must include surface smoothness" as a (specific?) paper requisite—just as it is with the other inks and processes.

"Gloss" and "High Reflectance" might similarly have to be included for the above and certain other effects. The present popularity of "cast-coated" papers and boards in all types of printing is such an example.

The pH of the Paper or Board is another characteristic that, at times, may be "specific" in its relation to, or influence upon, litho inks—explicitly, those that airdry by oxidation. Uncoated stocks of abnormally low pH (such as lower than 4.5) in many or even most, instances markedly decrease the drying rates of such oil inks, and are prone to "counter-etch" offset plates. Reed (*6*) in his work for LTF has stressed this point in text and by graph—we, and others, have encountered many such instances. At the same time, we have many times found that variable pH in the same lot of paper or board has given oxidizing drying-rate differences from sheet to sheet—or even "spotty" drying variances on the *same* sheet.

Good "Dimensional Stability" under moderately variable humidity and moisture conditions, is another general requirement that should be mentioned. This, of course, is particularly important in offset sheet printing in cases where it is necessary for the stock to undergo more than one press passage and keep "close register."

Good "Opacity," well-felted and uniform-fiber *"Formation"* and proper *"Grain Direction,"* are other general requisites, as in the case for all types of sheet-fed printing.

Controlled Moisture Content is particularly important in the litho sheet-fed printing of multicolor jobs on single- or two-color presses. *Preconditioning* to some 6 or 8% higher relative humidity, than expected at press-side time of printing, is a frequently necessary requirement. By such treatment, evaporative moisture loss during feeding and delivery is closely "balanced" by that added during damp-blanket impressional contact. Hence, good dimensional stability and register is maintained throughout the press-to-press printing.

The Final General Requisites, such as expected of any type of printing stock are: *uniformity* from sheet-to-sheet or roll-to-roll, absence of *external damage* and *internal faults*—and freedom from fuzz, lint, and cutter or slitter dust. The latter can be especially objectionable in offset printing—and far more dangerous than in letterpress—for reason of their tendency to stick to, and accumulate on, the moist blanket. Such slitter and coating dust, in addition to causing print disfigurement with "hickies" and "fill-in," may instigate the even more serious blanket and plate "piling" of ink and/or coating. Remember, that we have heretofore stressed this as being one of the banes of lithography.

AREAS WHERE PAPER AND BOARD COULD BE IMPROVED

It generally seems that the greatest problem the ink maker and lithographer presently have to contend with, in connection with paper and board, is *lack of proper uniformity.* Such nonuniformity may frequently occur in the lot-to-lot shipments from a given mill—but it seems to be even more frequent and marked in its variance of properties, in the same grade (and price bracket) of stock, from different suppliers or mills. It likewise seems as if such nonuniformity mostly occurs in property areas that include one or more of the first four of the seven "specific" paper-ink relationships that we have just discussed in our previous section.

Of these nonuniformities, variance, and deficiency, in "wet pick resistance," and its resultant troubles, seems to be the most frequent, and most responsible, for

Table I. The Different Effects of Various Clay Coated Boards on Gloss Ink Performance

Set rating blue	Stock no.	Gloss		Setting time & rating			Drying time, hr.	
		With blue ink	With orange ink	Finger method, min. Blue ink	Finger method, min. Orange ink	Set-off rating 5 min. Back-up blue ink	Blue ink	Orange ink
1	10	Good	Fair	3	12	Excellent	3 1/4	3 1/4
2	5	Fair	Fair	8	10	Excellent	4	2
3	6	Fair	Fair	8	10	Excellent	5	5
4	4	Fair	Fair	8	13	Excellent	2	2
5	11	Good	Fair	12	40	Good	4	4
6	13	Good	Fair	15	25	Excellent	3	3
7	3	Good	Fair	25	25	Good	5	4
8	2	Good	Fair	25	50	Fair	8	8
9	12	Good	Good	28	40	Fair	5 1/2	5 1/2
10	1	Good	Fair	30	30	Fair	8	8
11	7	Good	Good	30	60	Fair	4 1/4	3 1/2
12	9	Fair	Fair	55	90	Good	3	3
13	8	Fair	Fair	60–100	60–100	Poor	6	6 1/2

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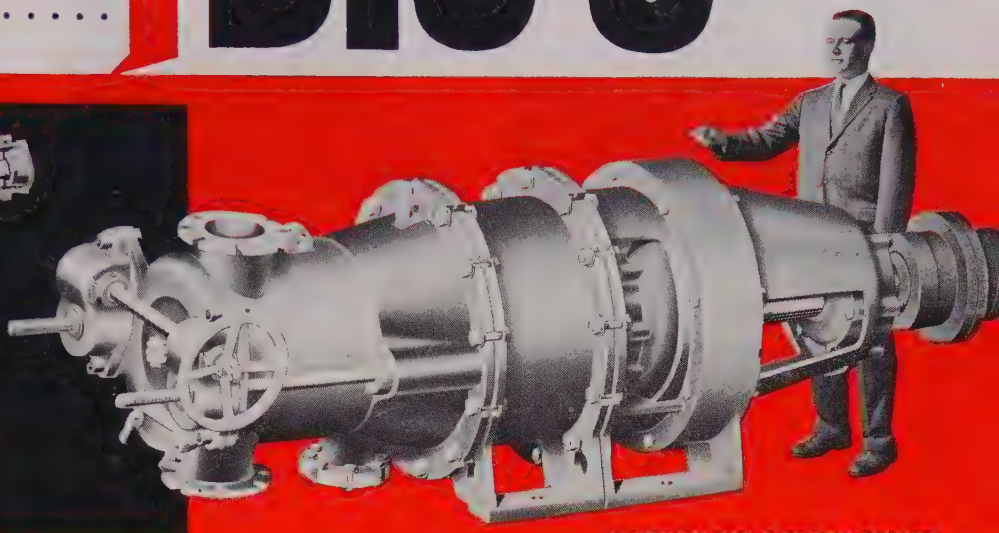
FIGURE 5. Big 8 Stock-Maker Refiner, illustrating reverse flow, cushioning principle. Stock enters hollow rotor at A, is forced between bars on rotor B and shell C where the opposing internal flow pressures hold a full cushion of stock, permitting heavy bar loading for maximum brushing, combing and fraying of the fibers. Cutting action is at a minimum.



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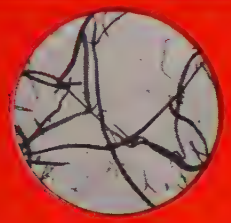

FIGURE 1. Untreated pulp. Freeness. 635 Canadian Standard. Tear factor, 85.

FIGURE 2. Medium treatment by Morden Stock-Maker. Freeness 300 Canadian Standard. Tear factor 85.

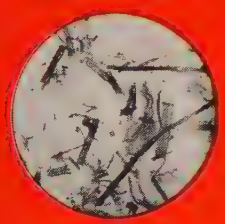

FIGURE 3. Medium jordaning treatment. Freeness, 275 Canadian Standard. Tear factor, 55.

FIGURE 4. Heavy treatment by the Stock-Maker. Freeness, 75 Ca

The perfect refiner is yet to be built. But, the development which comes closest to refining perfection, customers tell us, is the MORDEN BIG 8 REFINER. Here is the BIG MORDEN 300-400 H. P. engine which provides the maximum in stock treatment....Good Mullen • Improved tear retention • Excellent fold and tensile development • Printability specs met with ease through precision stock treatment.

THE SECRET IS MORDEN'S DEVELOPMENT OF THE FIBERS. The incompatibles, Good Mullen and Good Tear Retention at Minimum Freeness Reduction, are made compatible in the MORDEN BIG 8 REFINER through its brushing, combing action, which develops and frays the fibers with minimum cutting. The photomicrographs tell the story. FIGURE 1 shows unbleached sulphite prior to refining. FIGURE 2, the same fibers after medium treatment in the Morden Stock-Maker Refiner. Note the fraying and brushing imparted to each fiber. FIGURE 3, the same fibers treated to about the same level of freeness with a jordan. Notice how the fibers are cut, not frayed. FIGURE 4, the same fibers as Figure 2, except that the MORDEN refining treatment has been carried to much lower freeness. Even so, the tear in Figure 4, with twice as much MORDEN treatment, is better than figure 3 with medium jordaning.

HOW FIBER DEVELOPMENT IS ACHIEVED AND CUTTING MINIMIZED. Morden's unique reverse-flow principle, with opposing internal flow pressures, **provides a constant cushion of stock between the shell and rotor bars,** permitting maximum brushing and fraying, with minimum cutting of the fiber. SEE FIGURE 5. Result: GOOD MULLEN and EXCELLENT TEAR RETENTION at MINIMUM FREENESS DROP, INCREASED MACHINE SPEED & DRYER CAPACITY FOR INCREASED DAILY PRODUCTION.

POWER SAVINGS. Over and over again customers tell us that Morden Stock-Makers provide better stock treatment, yet consume less power . . . **in some cases savings up to 50% are reported.** A 400 H. P. MORDEN BIG 8 uses only 70 to 90 of its connected H. P. for idling load, leaving 310 to 330 H. P. for efficient stock treatment. Compare this efficiency with any other conical refiner, where usually up to 50% of applied energy is consumed for idling load.

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greatest loss in printing quality and productivity. The resultant "piling," that presently occurs in many instances of coated paper web-offset printing, is a typical example of lack of, or nonuniformity in, such wet pick resistance. Many times, on our four color web-offset press, we have induced "coating piling" without the use of *any* ink—just to prove such cited coated papers' deficiencies. Consequently, this seems to be a most important area where paper and board could be possibly improved for lithographic or offset usage.

Two aspects of such possible improvement, taken individually or in combination, could be: (1) better maintenance in wet pick resistance of whatever is now considered standard in a given paper or board grade— and, (2) raising the pick proofness standards wherever possible—so as to obtain a higher factor of safety, or insurance, against pick occurrences and troubles.

Another increasingly evident nonuniformity of same-grade, different-mill coated, boards, is in their gloss ink "set-times" —as illustrated in Table I.

The gloss blue and orange inks used in the above tabulated tests were representative of the heretofore described "quick-set" type that is becoming increasingly used in offset work on both coated papers and boards. In the case of the blue ink, initial surface-set times that range from 3 min. to over an hour, indicate the great variance we have mentioned. While this initial set is not necessarily directly related to final gloss or drying—it is, nevertheless, very important as it is in most cases directly indicative of delivery pile "setoff" tendencies, as is shown by comparison with the table's 5 min. "back-up" results. Also, since this table shows that only about one half of the boards gave better than a "fair" gloss rating—even though printed with these highest-gloss inks —this indicates needed im-

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even have applications of "reverse lithography" where ink and image are hydrophilic, or water wettable, and the nonprinting areas are kept in such state by being hydrophobic or water repellent.

However, it presently seems rather likely that some sort of water-dampening mechanism will continue to be used for an appreciable time in the close-by future—and the inks will maintain their present oil-miscible nature. Even so, it is equally evident, there will be continued improvement in dampening refinement to the extent that an absolute minimum of moisture can be applied, and uniformly maintained, on the nonimage areas of what will be continually improved plates. The recent developments of the Dahlgren and Lithoprint dampening systems—as well as the introduction of special paper wrapping (in lieu of cloth) on the dampeners—are evidence of such trend. The obvious consequence of such present and future improvements will undoubtedly result in greatly diminishing ink and paper's present burden of "ordeal by water"—and give the makers of both ink and paper more latitude in the makeup and manufacture of their products.

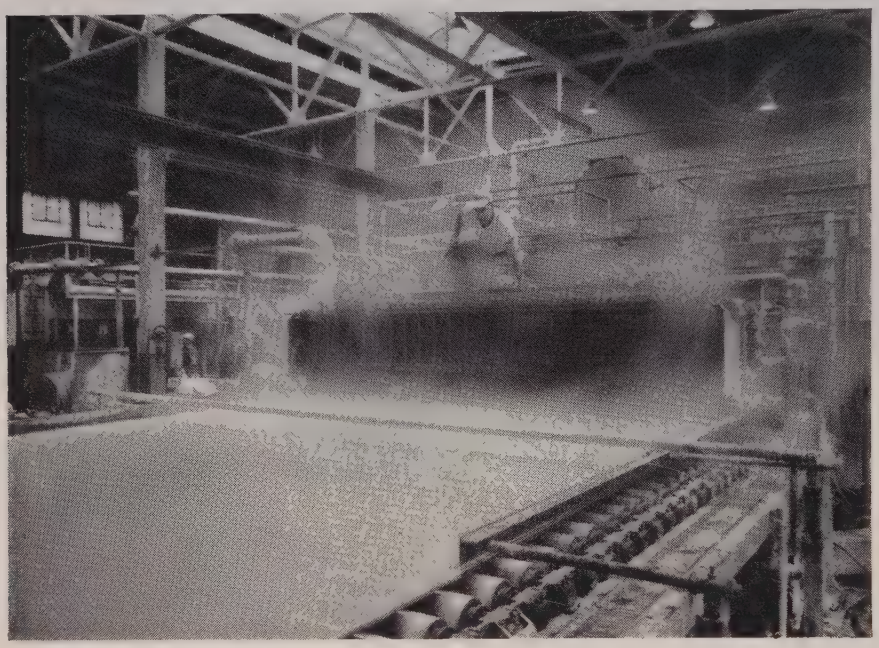
Future Offset Inks Will Be Softer and Faster Drying—to Suit Faster Printing Speeds

As a result of the above wider latitude, future offset inks will continue to be made "softer"—until they will probably match the tack and viscosity of equivalent-job letterpress formulation. Present experimental printings at Rochester Institute of Technology, indicate web-offset inks can be made soft enough to print multicolor work satisfactorily on 32-lb. standard newsprint at speeds over 1200 f.p.m. (7). The authors' company has frequently run such kind of soft inks at 900 f.p.m., on its four-color web offset press, on similar low-pick news.

Such allowable use of softer offset inks, will permit the heat-set variety to be formulated to dry faster and run at much greater than present web-speeds. These inks could, even now, be constructed to dry at the maximum speed of any present production web-offset press—provided the latter is equipped with the proper heater and cooling assemblies.

At the recent, 1960, annual meeting of the Web Offset Section of PIA (*8*) mention was made of contemplated new increased offset publication printing speeds of up to 2500 f.p.m. Needless to say, such terrific peripheral speed increment will necessitate drastic changes in both ink and paper, as such rates will greatly surpass all present speed limits. Present speed limitation has been the vulnerability of present papers to "moist-pick" and "piling." In turn, the latter has been caused by inks that had to be maintained at relatively high tack in order to safe-guard against "emulsification" and "low viscosity tint"—as might be otherwise caused by softer inks as run with present excess-water dampening applicators.

It seems doubtful that sheet-fed offset inks will ever attain the split-second drying of heat-set web printing. However, continued drying speed increment in lines of "paper-ink reactions," and dampening or otherwise applied "catalytic action, should enable future formulation to furnish inks that will be "completely" dry by the time the



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3–90	45–55	2–4	99–97.9
20–90	35–45	19.5–22.7	89–87
1–60	28–32	0–2	100–99
3–60	23–28	2–4	99–97.9
20–60	21–25	19.5–22.7	89–87
1–30	4–6	0–3	100–98.5
20–30	4–6	19.5–21.5	89–87.7
40–20	2–3	37–42	77–72.9
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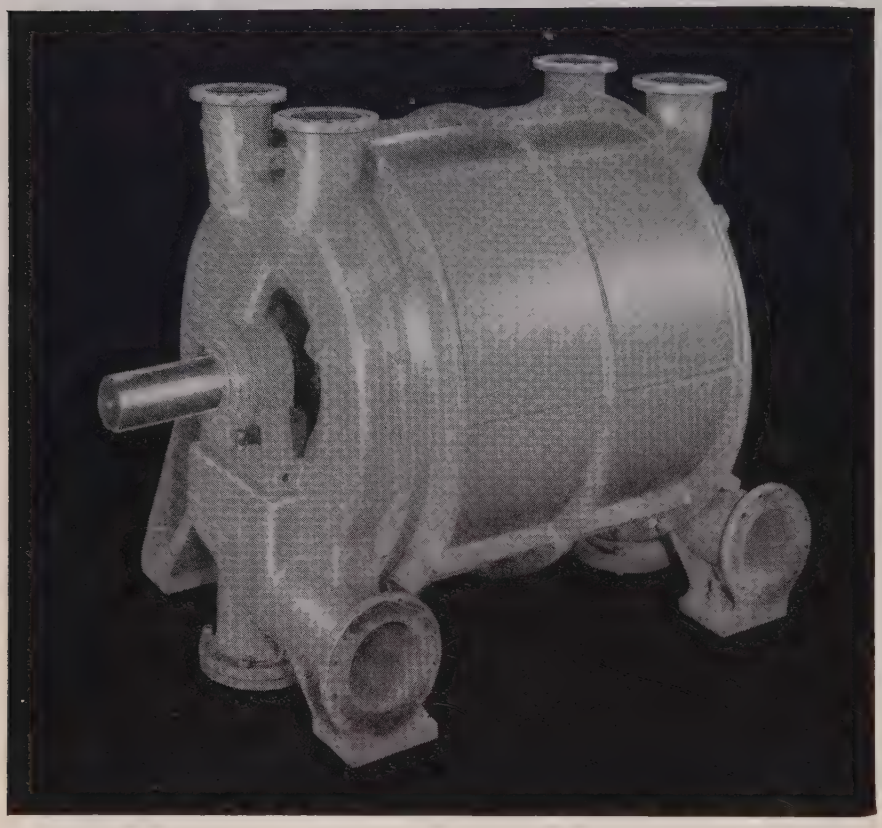
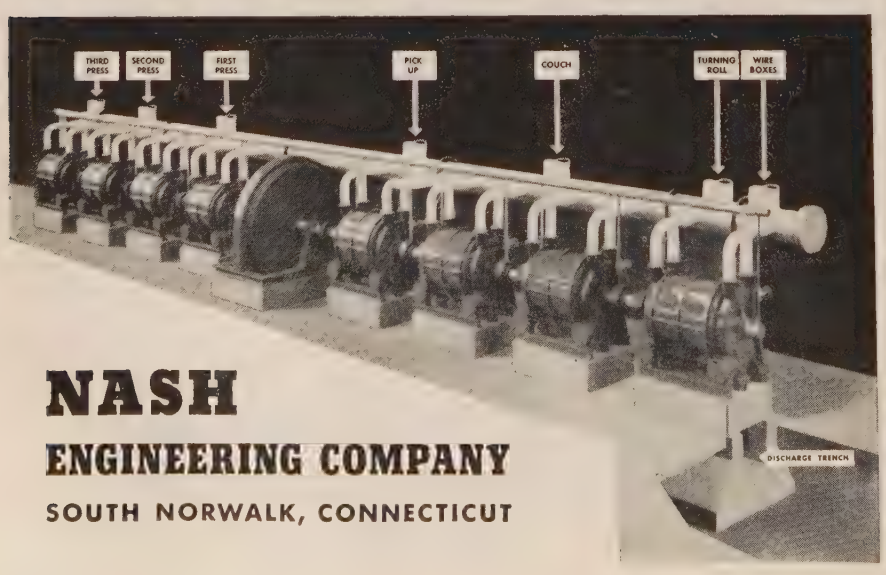


The Nash 5308-A has four separate suction inlets, each of which functions independently of the others. This offers the machine operator great flexibility, since these may be used in any desired combination to produce a variety of capacities and vacuums.

Picture below shows simple drive possible and flexibility of piping permitting capacities to exactly fit requirements of different sections of the paper machine.



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sheets arrive at the delivery pile. Additional significant future development is expected in offset ink application on film, foil, plastics, and metal—but so are future advancements anticipated for paper and board. Some such future developments and improvements in inks for the latter that seem certain to follow, should result in new inks that will be: more permanent, more brilliant, tinctorially stronger, better color balanced and closer to process printing "ideals," more resistant for functional and end usage, and better suited to the expected higher printing speeds—and to whatever might be the automative demands of future offset application and processings.

CONCLUSION

In conclusion, it must seem rather ironical that today's paper—which, for reason of the dampening requisites of lithography, has given us more printing trouble than any other material—should, itself, in form of paper strip or sleeve dampener cover, have just recently given us one of the present most noteworthy improvements in that selfsame dampening system. Paradoxical though such example may seem, it illustrates the ability of the paper makers to thus ingeniously modify their products to suit given end-usage demands. This augurs well for their future development and cooperation in improving their product for better ink-paper litho relationships. It also predicts that such cooperative ink and paper work will soon take the guess out of that frequently asked question, "Will it lithograph?"

LITERATURE CITED

1. Roehr, W., *Printer and Lithographer* 145, No. 2 (May, 1960).
2. Reed, R. F., "The Inkometer," Tech. Bul. No. 2, Litho Technical Foundation, 1939.
3. Oehme, F. F. and Nepper, D. C., *Tappi* 43, No. 10: 174A–176A (October, 1960).
4. Fetsko, J. M., Lehigh Printability Symposium, Sept. 11, 1959 (New York City).
5. Hartsuch, P. J., "Chemistry of Lithography," Publ'n No. 401, Litho Technical Foundation, 1952.
6. Reed, R. F., "What the Lithographer Should Know About Paper," Tech. Bull. No. 8, Litho Technical Foundation, 1959.
7. Anon., "Web-Offset for Newspapers at RIT," *Modern Lithographer* 28, No. 4 (April, 1960).
8. Anon.,| "Web-Offset Ink Problems," *National Lithographer* 67, No. 12 (December, 1960).

Presented at the 46th Annual Meeting of the Technical Association of the Pulp and Paper Industry, held in New York, N. Y., Feb. 20–23, 1961.

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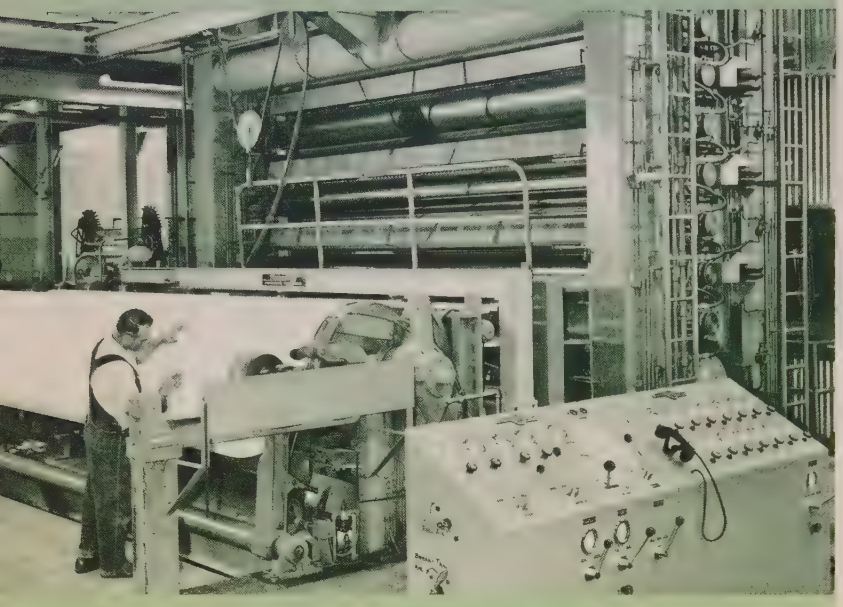
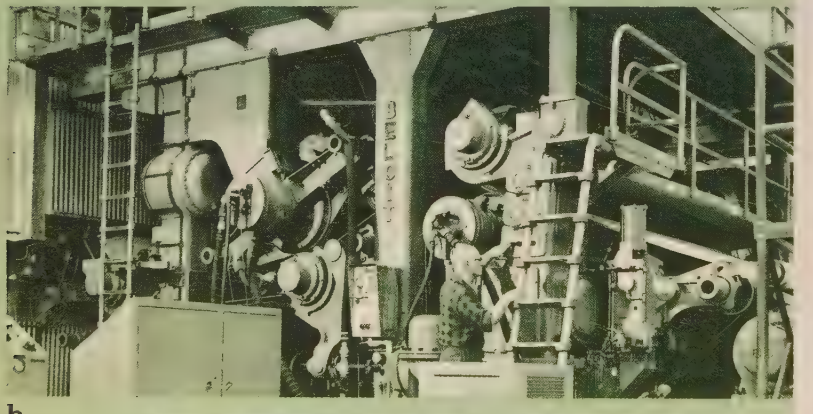
(a) Beloit LLR reel with 36″ constant speed drum. Control console is arranged for maximum operator convenience. **(b)** Straight-through press. Note inverse, air bleed second suction press and open draw arrangement for effective transfer of sheet from wire to felt. **(c)** Beloit Type E air-cushioned inlet and removable Fourdrinier. **(d)** Horizontal size press following main dryer section designed to apply size or light coatings. **(e)** Calender stack equipped with patented nip relief arrangement.





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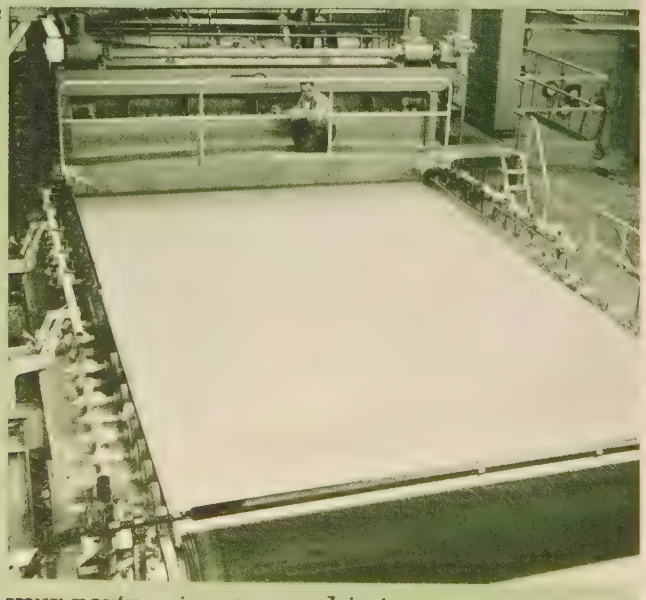

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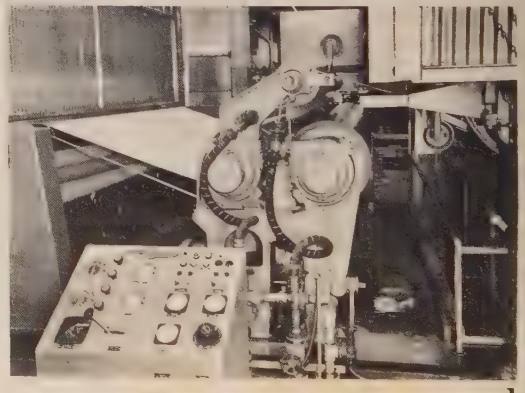

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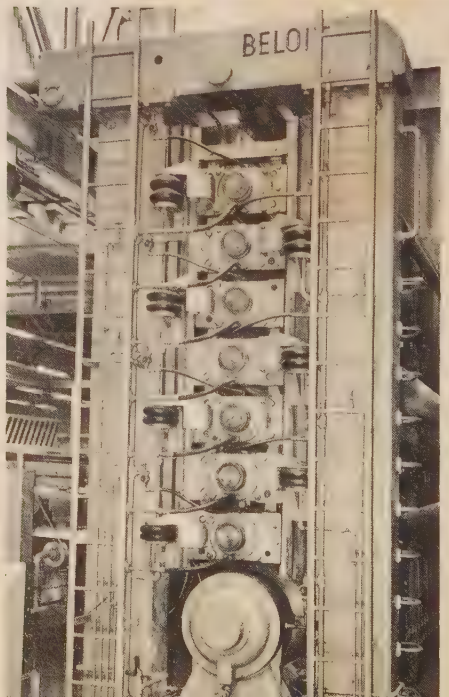

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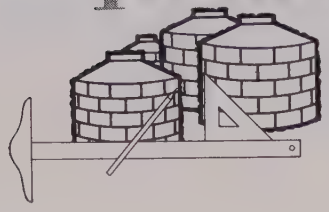

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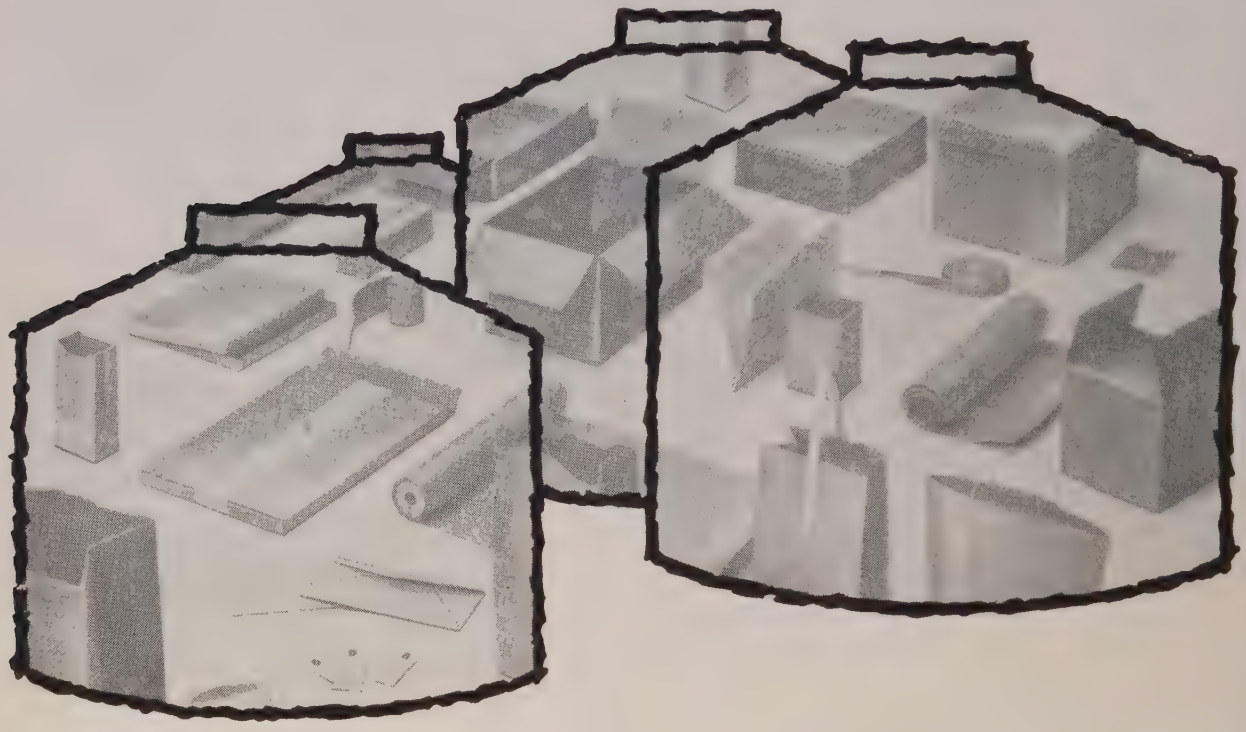

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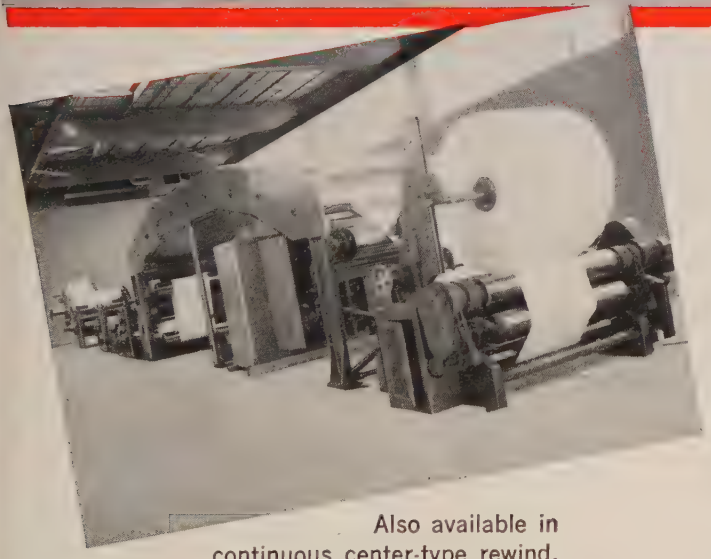

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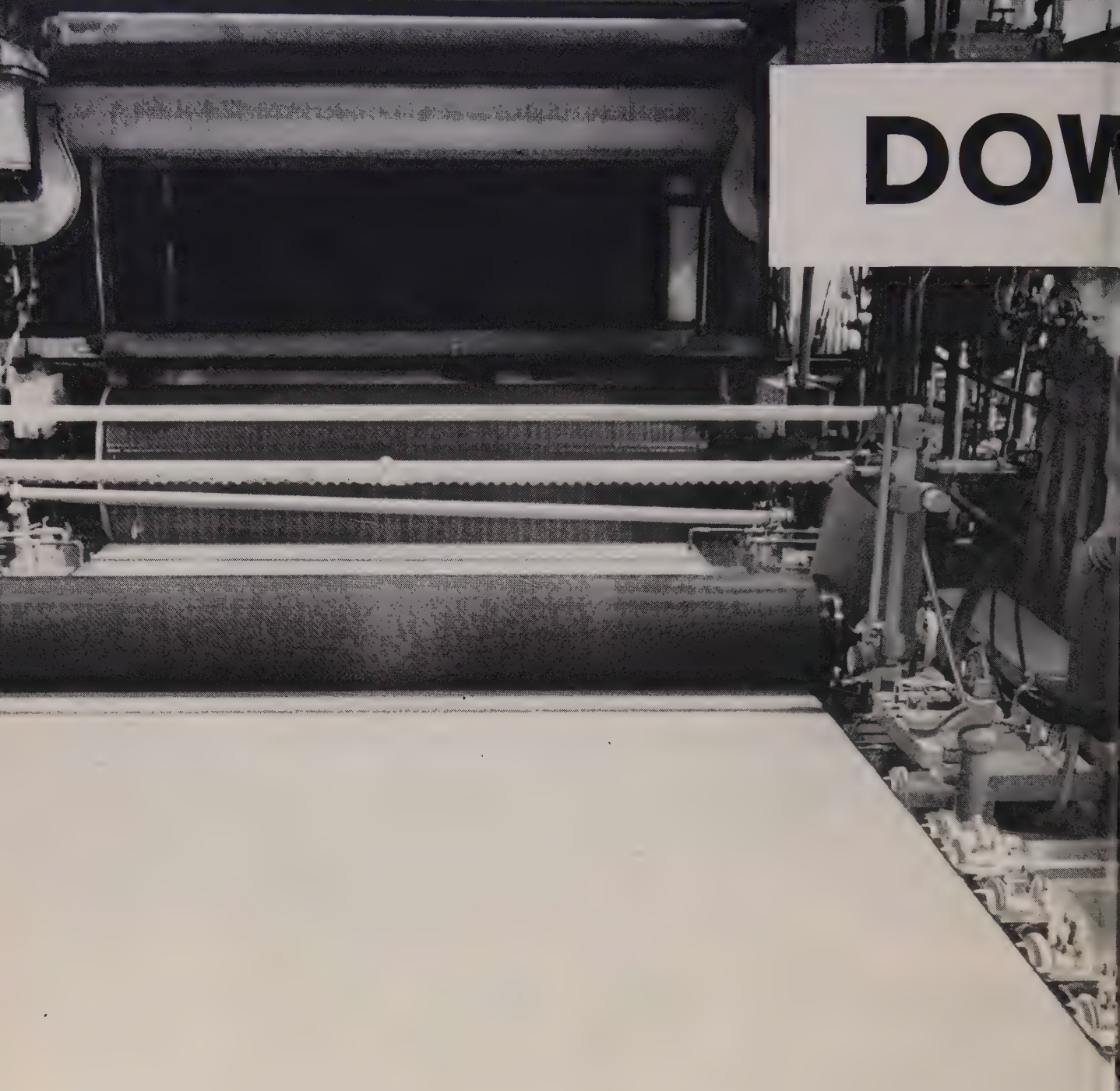

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	0.5	310	0	10.3	90.2	$4.30
30 lb. MAGAZINE	NONE	600	0	14.8	74.0	
	0.4	375	0	14.1	74.0	$4.10
60 lb. OFFSET BOND	NONE	550	30	12.2	92.0	
	0.5	400	30	13.7	92.0	$2.50
25 lb. MACHINE COATED CARTON WRAP	NONE	50	150	12.2	77.0	
	0.75	50	125	13.2	76.0	$5.50
50 lb. OFFSET BOND	NONE	370	145	9.6	89.0	
	0.6	145	100	12.6	90.5	$15.15

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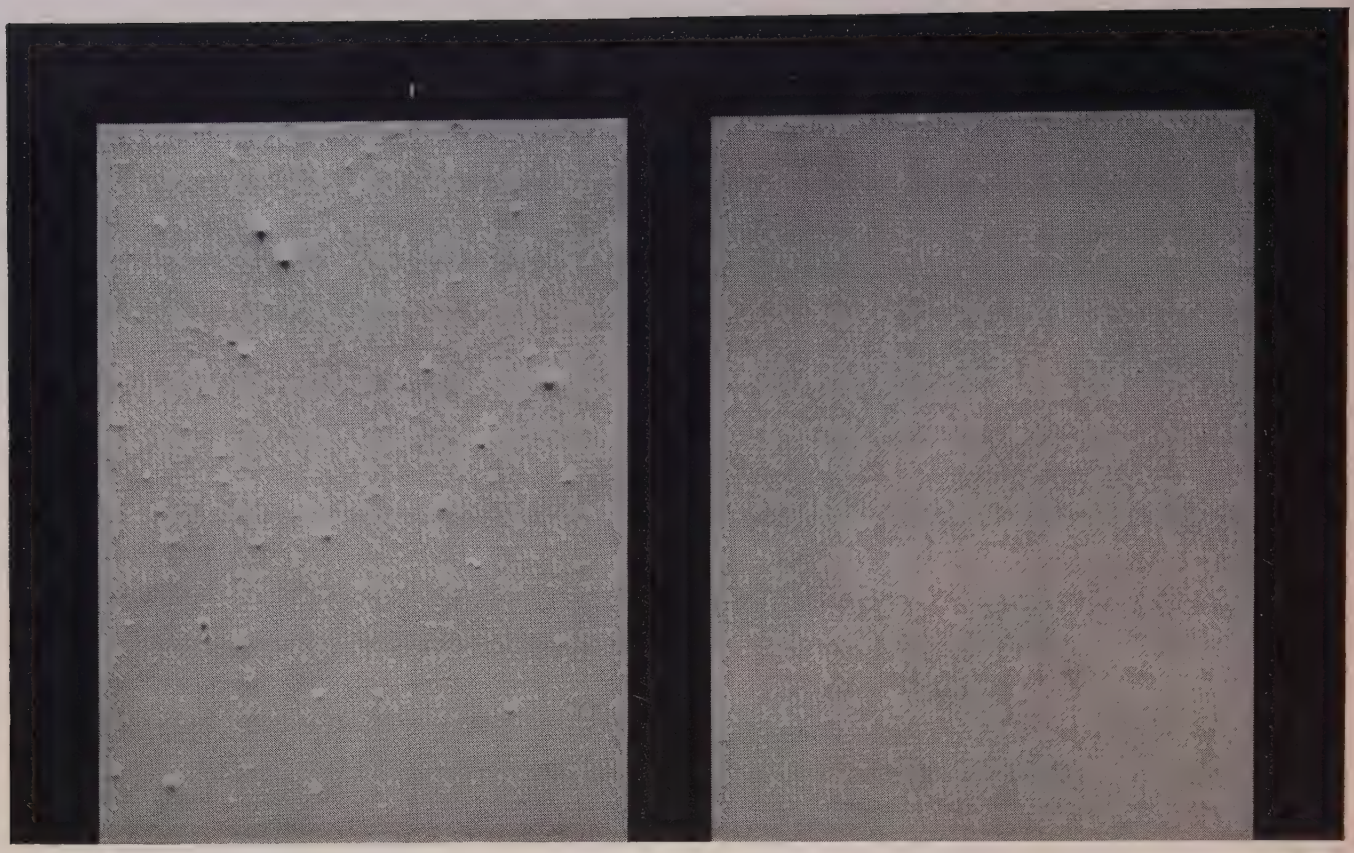

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Your specifications ("specs.") for coatings can well include TITANOX-A-CG, the Coating Grade anatase titanium dioxide pigment.

Made expressly for paper coatings, this pigment is controlled by rigid specifications that maintain not only whitening, brightening and opacifying power, but also the ease of fine dispersion and the freedom from coarse agglomerates that help banish specks.

For your coatings that must be produced and used with the utmost speed and still yield surfaces of uninterrupted smoothness, let TITANOX-A-CG be your choice in titanium dioxide.

Titanium Pigment Corporation, 111 Broadway, New York 6, N. Y.; offices and warehouses in principal cities. In Canada: Canadian Titanium Pigments, Ltd., Montreal.

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TITANIUM PIGMENT CORPORATION
SUBSIDIARY OF NATIONAL LEAD COMPANY

ANYTHING YOU CAN DO WE CAN DO SMALLER

WHEN IT COMES TO TESTING PARAFFIN COATINGS FOR ANY SPECIALIZED NEED

The table-size model pictured here is really a *complete* wax-coating machine. With this and our other lab equipment, Atlantic technicians can match conditions you'll encounter when you're coating paper stock with paraffin for any commercial purpose. This is possible because every factor present in wax-coating operations also is present and can be carefully controlled on these ingenious testing devices.

First, Atlantic researchers check the wax temperature, paper speed and chilling bath to make sure they agree exactly with the information you've furnished our Sales Engineer. Then they determine by informed experimentation the proper waxes required for seal strength, moisture resistance, blocking, slipping or whatever characteristics are necessary to solve a specific paraffin coating problem.

This paper-coating machine is typical of the testing equipment used in the Atlantic Research Department to assist you in serving your customers. Others include our exclusive Imflex Tester for determining impact resistance and flexibility . . . the Seal Strength Tester which measures the force-per-inch necessary to separate wax paper laminations and seals . . . and tests for gloss, resistance to grease and for finding the coefficient of friction on waxed surfaces.

Your Atlantic Sales Engineer will be happy to assist you in solving your wax-coating problems. His years of specialized experience should prove invaluable in helping you select the paraffin blends best suited for your own requirements. And his on-the-spot technical assistance is backed by the complete facilities of the Atlantic Research Department.

ATLANTIC

CHOOSE FROM OUR FULL RANGE OF HIGH-QUALITY WAXES TO MEET YOUR PAPER-COATING NEEDS

Philadelphia, Pa. • Providence, R.I. • Syracuse, N.Y. • Pittsburgh, Pa. • Charlotte, N.C.

ONE DILUTION takes 12% stock down to a uniform 5% in dual-purpose chest at Canada Paper Company, Windsor Mills, Que.

See the two stock chests in this picture?

Engineers at this mill solve a serious storage problem—by making this *one* stock chest do the work of *two*. A LIGHTNIN Side Entering Agitator helps them do it.

High-density unbleached kraft stock feeds into the 60-ton chest from the brown-stock washers at a consistency of 12-16%.

Out of the same chest comes stock diluted to a uniform 5%. It goes right to the refiners. No second chest is needed for leveling out consistency fluctuations. Refiners operate smoothly—even though there's no consistency regulator in the system.

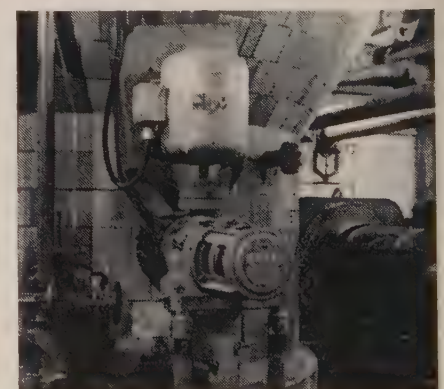
How it works

Mixing takes place in the chest bottom. Here, in an 8-foot-deep zone of reduced diameter, the LIGHTNIN Agitator swiftly and continuously blends stock with incoming dilution water. Consistency of stock anywhere in this zone varies less than 0.1% (bone-dry basis) from the specified average.

There's no need for auxiliary high-pressure jets. Stock above the mixing zone can't stagnate or channel. It moves downward in fully predictable plug flow, is peeled off steadily by the agitator, and is rapidly and evenly diluted to 5%.

This is no accident. When you use LIGHTNIN Agitators in your stock chests, you can specify exactly the performance you want—*and get it.*

Let your LIGHTNIN representative show you how. His name is in Thomas' Register. Or write directly to us.



FROM THIS ZONE, stock goes directly to refiners, mixed to within ±0.1% of required consistency by the LIGHTNIN Side Entering Agitator.

Lightnin® Mixers

MIXCO fluid mixing specialists

MIXING EQUIPMENT Co., Inc., 142-g Mt. Read Blvd., Rochester 3, N.Y.

In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Ave., Toronto 19, Ont.

In Europe: Lightnin Mixers, Ltd., Poynton, Cheshire, England

news from Du Pont

PROVIDENCE LAB ANALYZES SCORE OF PAPER SHADES IN TYPICAL "ECONOMY CHECK" FOR NEW ENGLAND MILL

Taking advantage of Du Pont's Economy Check program, a progressive New England mill recently submitted more than 20 of its colored papers for thorough analysis by our Providence laboratory. The Du Pont specialists are looking for ways to improve quality and/or reduce cost by reviewing completely the recommendations for each mill shade.

"It must be a thorough study," says Wes Killheffer, technical supervisor of the Providence District office, "so we can assure mills that they are using dyes most effectively, most economically."

Frank Desmond, Du Pont Dyes & Chemicals technical representative, is in charge of the Economy Check in New England. Along with lab technicians Albert Watson and Charles Lenderson, Desmond strives for these three objectives:

1. Upgrade quality (for example, fastness to water or light) by suggesting alternative dyes.

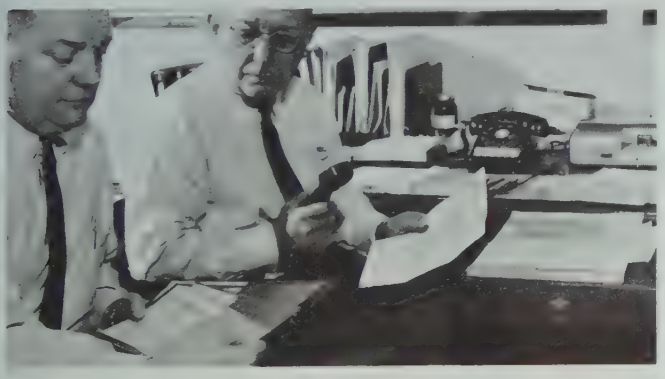
2. Improve mill efficiency by recommending dyes that are easier to control and thus insure more uniform results.

3. Save money by suggesting cheaper dye formulas that will do a satisfactory job.

The laboratory recommendations, of course, are only part of the Economy Check story. The revised formulas are then taken back to the mill by Desmond or another Du Pont representative for demonstration or trial. Additional work may be required to tailor the recommendations to mill requirements.

In addition to long-range Economy Checks, the Du Pont lab people function as "short-order cooks," matching color shades for mills swiftly and accurately. The shade matching requests come in by mail, phone, or via the Du Pont salesman. The lab makes an average of four matches before recommending a formula for mill trial.

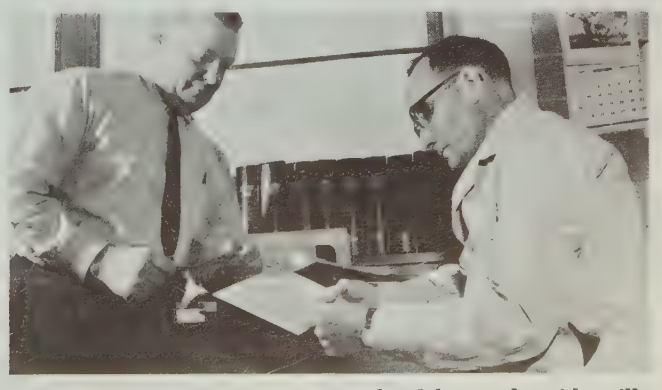
Now serving 173 paper mills in the New England area, the Rhode Island installation is one of five Du Pont labs working for the paper industry. All of them stand ready to help you with your paper dyeing problems.



Frank Desmond (left) and Wes Killheffer outline scope of typical Economy Check in detailed Providence lab memo.

Albert Watson, lab technician, using same "furnish" that the mill uses, carefully adds dye to the pulp, then stirs.

After dye and pulp are thoroughly blended, the mixture is poured into a mold where sheet of paper is formed.



Desmond and Watson compare dry lab sample with mill sample to see that they have a satisfactory shade match.

SURVEY SUGGESTS DU PONT "DESIGN/COLORED PAPER" SERIES HAS SPURRED USE OF COLORED PAPER

Two years ago Du Pont launched a Colored Paper Marketing Program to help paper mills and paper merchants promote the use of colored stock by graphic designers and printers. In addition to a highly noted advertising campaign featuring nationally recognized designers in trade magazines, Du Pont started mailing a publication called "Design/Colored Paper" to a special list of artists and printers. It demonstrated new and effective applications for colored paper in the graphic arts.

To check the results of this effort, the Dyes and Chemicals Division recently mailed a questionnaire to the 2897 designers and printers on the list. A whopping 41 per cent returned

the questionnaire, and subsequent compilation of answers revealed:

1. Exactly 75 per cent said that D/CP ideas influence them to specify more colored paper than formerly.

2. A huge majority want still more information and inspiration.

3. Most want more help on colored paper from paper marketers. Only one out of five had been visited by a paper salesman who mentioned "Design/Colored Paper." And more than one out of three never even see a paper salesman!

news from Du Pont

NEW PAPER WHITE SPS ADDED TO "BRIGHTENER" LINE

Du Pont Paper White SPS Solution is our newest white dye for paper. It is a clear solution and it exhibits excellent buildup properties when surface-applied over the pH range of 4.0 to 8.5. It also can be applied in the beater over a wide pH range and is non-graniting.

The same dye is available in a weaker concentration, designated Du Pont Paper White SPSW Solution.

See your Du Pont representative for more information and to arrange for a mill trial.

New Report: The Effects of Dyes on the Opacity of Paper

There is growing demand in the industry for lightweight papers with high opacity. The trend toward higher postage rates on publications is partly responsible for this, making it desirable to reduce the basis weight of printing papers without loss of opacity. Increased opacity for a given fiber furnish can be achieved by the use of additional pigment filler, or a filler of increased refractive index, or by use of dyes.

A paper on this subject, co-authored by Du Pont's Mason Hayek, Albert S. Deutsch and Joseph P. Neary, was delivered by Hayek at the TAPPI annual meeting in February. It describes the effects of dyes and colored pigments on opacity, discusses the relationships between hue, opacity and brightness for tinted, pastel and deep shades, and points to practical applications of the principles. This report, along with Du Pont Color Orientation and Opacity Charts, is available free by writing E. I. du Pont de Nemours and Co. (Inc.), Dyes and Chemicals Division, Nemours 8520, Wilmington 98, Del.

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Wilmington 98, Delaware

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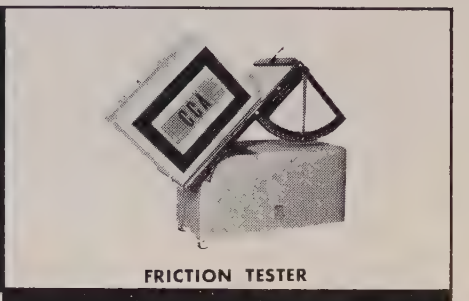
TORSION TEAR TESTER



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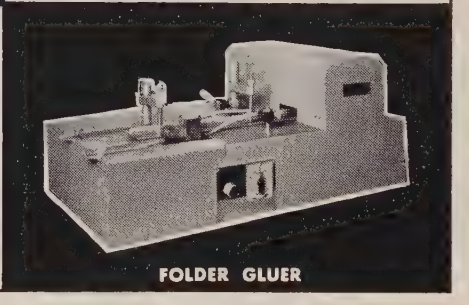

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The addition of these CONCORA instruments to our line of fine testing machines is just one more reason why —

"more people — in more places — are testing more things with TMI equipment"

Additional units:

- **Liner Test Jigs**
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- **Specific Gravity Tester**
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LATEST EDITION EXTRA

Special Announcement Issue

SERVING THE BUSINESS WORLD — Published in The Public Interest — VOL. X . . . No. 5002

PORT RID LITTEBLY

Assails Pert Vews Fiold in Merri

TON, June 1 — Peter Treling bitterly de of New York newest report port in Merris

Burson, a Re- chairman of Site Associa- posing the jet- hat His group the and, and ever be a jet- County."

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Nation's Pulp Makers Benefit from a New Product: "PULP-AID!"

ONCE AGAIN, STEIN HALL RESEARCH ACHIEVES A MAJOR "FIRST!"

Stein Hall leadership has achieved another important breakthrough — this time for the Pulp Making Industry!

The key to this breakthrough is "PULP-AID" — a new member of the Stein Hall family of galacto-mannan gums. PULP-AID — added to dry lap pulp *before* shipment to paper mills gives the pulp the following added advantages:

- improvement of bursting and tensile strengths and folding endurance, as well as tearing strength
- utilization of higher percentages of short-fibered pulps and pigment fillers at constant sheet strength
- decreased refining or horsepower requirements
- increased mill capacity by speeding up pulp refining
- attainment of better fiber distribution or sheet formation
- attainment of combinations of properties otherwise difficult to obtain in a given furnish. For example, the use of PULP-AID added to pulp will enable a paper maker to obtain the strength he requires without loss of absorbency.

With Stein Hall PULP-AID, pulp makers can produce and sell a greatly improved product.

For samples and further information about Stein Hall PULP-AID write the Paper & Corrugating Department.

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285 MADISON AVE NEW YORK 17, N. Y.
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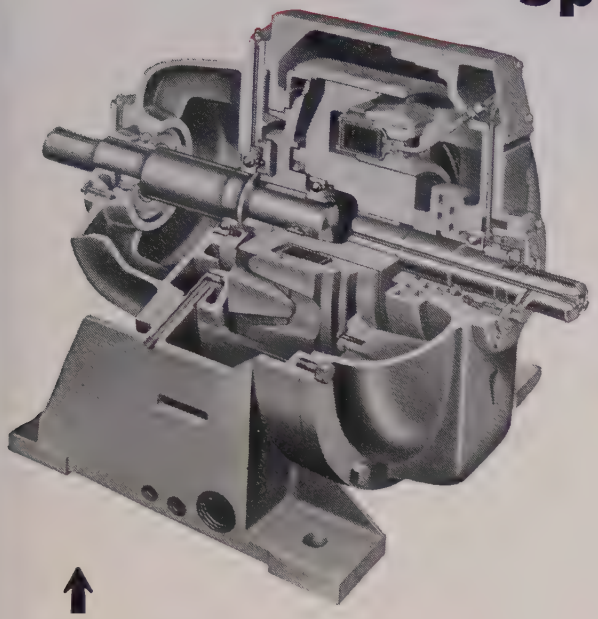
The BEST Solution to Difficult Speed Control Problems—

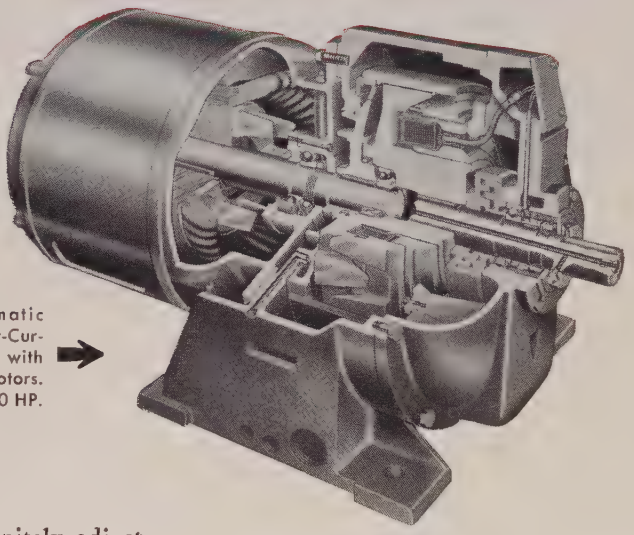


Dynamatic Liquid-Cooled Couplings provide infinitely adjustable speeds for nearly every application from 3 to 150 HP. Note the absence of slip rings, brushes, and commutators. Heavy-duty types with capacities up to 5,000 HP are also available.

EATON

DYNAMATIC®

LIQUID-COOLED EDDY-CURRENT COUPLINGS and DRIVES



"Dynaspede" Drives are Dynamatic Liquid-Cooled, Stationary-Field Eddy-Current Couplings mounted integrally with standard, D-flange, squirrel cage motors. Available in capacities from 3 to 150 HP.

Here's Why—

Dynamatic Liquid-Cooled Couplings and Drives provide infinitely adjustable speed from a constant speed source—or constant speed from a variable speed source. They operate on standard alternating current. Rotary power is transmitted through the coupling by an electromagnetic reaction between the driving and driven members of the unit—there is no mechanical contact of rotating members to cause wear and require adjustment or replacement.

A wide range of standard and special control features may be obtained from a remotely-mounted electronic control system. Infinite speed adjustment, constant speed control, on-off clutch control, torque limit, acceleration control, inching, and threading are a few of the many functions available. The addition of an eddy-current brake to standard couplings or drives provides smooth, cushioned stops and controlled deceleration.

Liquid-Cooled Dynamatic Couplings and Drives deliver more horsepower than other types of the same physical size, thus conserving space in a busy machine area. Efficient heat dissipation permits continued operation at low speeds, or stall with full load.

Completely enclosed, Dynamatic liquid-cooled units are protected from dust, dirt, and other atmospheric impurities. Dynamatic design involves no brushes or slip rings; there is no possibility of arcing. With simple modification these units can be made explosion-resistant for hazardous applications.

Infinitely Adjustable Speeds from AC Power

★

Smooth, Quiet Operation from Cushioned Starts

★

Wide Range of Control Functions

★

No Slip Rings, Brushes or Commutators

★

Completely Enclosed Design

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Greaseable Bearings

Send for Our New Illustrated Bulletin.

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DYNAMATIC DIVISION

MANUFACTURING COMPANY

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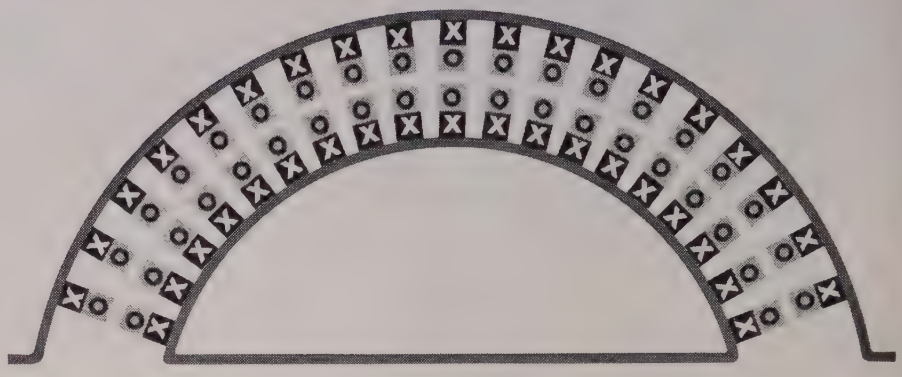
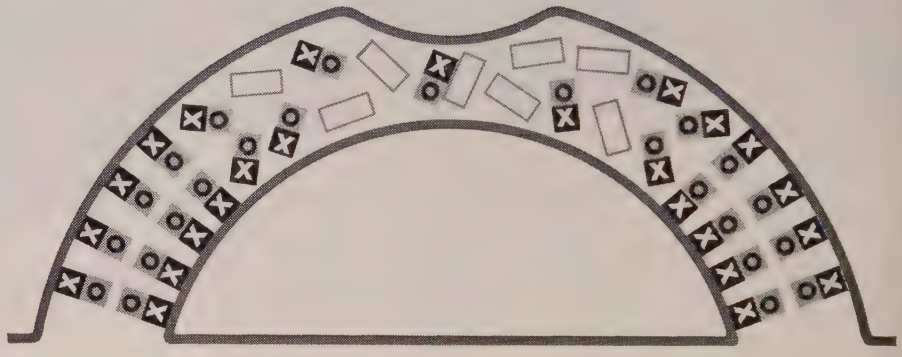
The make-up and break-up of foam

Foam, of course, is made up of bubbles. But, all bubbles do not form foam. For instance, pure water will not foam. If you take a glass or a beaker of pure water and bubble air through it, the bubbles will be large and will rapidly rise to the surface and burst. Several smaller bubbles may even join together and rise to the surface. But even these burst at the surface. There is no tendency to form foam.

Now, add just one drop of detergent—a surface active material—to this same water, blow air through it and foam develops. The bubbles are relatively small and there is no tendency to coalesce. This foam-causing difference is due to the surface activity of the detergent molecules.



Bubble Cross-section



Bubble with Defoamer Added

The Make-Up of Foam

Each surface-active molecule has a "water-loving" end and a "water-hating" end. These molecules arrange themselves in an orderly fashion in the liquid film of the bubble with their "water-hating" ends toward the film surfaces and their "water-loving" ends buried in the liquid interior of the film. It is this arrangement of molecules that gives strength and elasticity to the bubbles and keeps them from bursting.

The Break-Up of Foam

Anti-foam agents act either by completely displacing the surface film or by modifying its film-forming properties so that it no longer forms a stable foam. Therefore, a good defoamer must be capable of entering the liquid interior of the bubble film and modify or break-up the molecule arrangement that sustains the bubble film. Thus, since the defoamer has to work on only a small quantity of surface active material, only a relatively small amount of defoamer is needed.

What Causes Paper Mill Foam?

Some impurity, intentional or otherwise, must be present before foam can be produced. The most persistent foams are produced when the impurity is a surface active material such as carbohydrates, lignin, dyes, black liquor soaps, slimicides, sizes, etc. Since a foam condition can be caused by any one—or several—of these materials, no single defoamer will fill all needs economically. Houghton's "Personalized Paper Mill Service" was instituted to provide this "diagnosis and curative" service with proven De-Airex defoamers. If you have a foam problem in your mill, call your Houghton man or write and request this technical help. It's yours for the asking and may save you untold headaches and expense. E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa.

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LONGER BAR LIFE

MORE UNIFORM REFINING

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. . . eliminates vibration

METAL TO METAL CONTACT
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SIMPLE CONSTRUCTION
. . . easy to strip and fill

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. . . 29% of the bar is within the plug body

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Specify ADAPTA-PLUG* for better results at lower operating cost. Adapta liners available for older plugs.

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Mathieson SQUEEZES your caustic delivery costs

How? Many ways. For example, in most areas, you can order 73% Mathieson caustic soda by truck. The benefits to you are obvious. This concentrated solution means fewer deliveries, less shipping weight, less transportation cost. And only Olin Mathieson offers you this convenient truck delivery.

More ways Mathieson squeezes delivery costs? Location. Mathieson has eight producing plants and shipping points (with a ninth under construction) covering the industrial South and East, with barge, rail or truck shipments to suit your needs. Convenient truck scheduling: we time deliveries when you need them. Service: as you have a right to expect, it's part of company policy, backing every Mathieson chemical with technical assistance. For full details, write OLIN MATHIESON, Baltimore 3, Maryland.

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8947

CHEMICALS DIVISION Olin

if
. . . you are making a filled sheet—and
. . . you would like to increase the ash content, opacity or brightness of your finished paper without increasing your usage of fillers—or
. . . you want to maintain your present standards while reducing usage of clay and pigment—

THEN . . . we suggest you investigate the use of DARLING'S IMPROVED BONE GLUE as a wet end additive.

We've learned that every paper mill, including your own, is "different." That's why a cooperative mill trial is the best way to get a technical and economic evaluation.

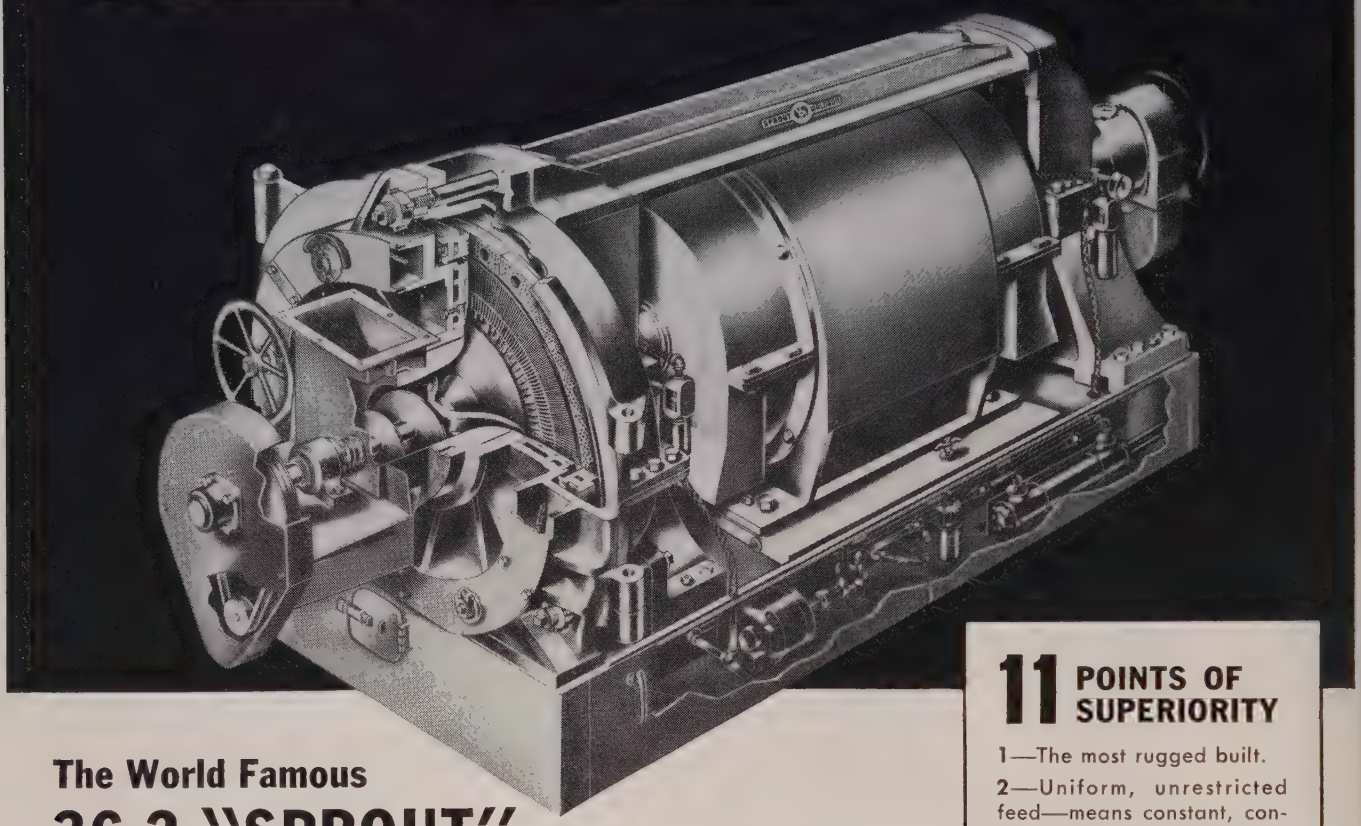
Our Technical Service Representative would like to work with you in determining what can be accomplished in your mill. The cost of the glue and technical service are on us, so you've nothing to lose—much to gain. Arrangements can be made through your Darling Sales Representative. Or write, call, or wire us direct.

DARLING & COMPANY
GLUE DIVISION
4201 South Ashland Avenue • Chicago 9, Illinois

DARLING'S improved BONE GLUE

EFFICIENCY

in quantity . . . in quality of refined pulp



The World Famous

36-2 "SPROUT"

single disc precision pulp refiner

The 36-2 Sprout is the most efficient disc refiner *in quantity of output and in quality of refined pulp* per horsepower input. It is preferred throughout the industry for every pulping application where rubbing and brushing action, without cutting, is required.

Sprout-Waldron units lead the field in the refining of semichemical pulp, cold caustic pulp, screen rejects, wastepaper stock; brown stock and hot stock refining of high yield kraft pulp; refining of bagasse, flax and straw pulping; as well as preparation of insulation and hardboard fiber.

Write for Bulletin 96-C for the latest details on the 36-2 Sprout.

SPROUT, WALDRON & CO., INC.

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11 POINTS OF SUPERIORITY

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3—Assured parallel plate operation through 3 point suspension tramming.

4—Peripheral control ring for greater refining control.

5—Top tension bar for balanced machine stresses.

6—Kingsbury thrust bearings for refiners with 600 to 1500 horsepower, inclusive.

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8—Integral oiling system.

9—Swinghead design for simplified plate changing.

10—High production with efficient, full utilization of connected power.

11—Proved to give minimum maintenance.

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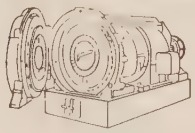
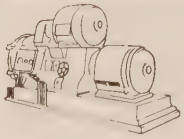
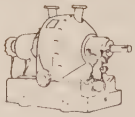
MORE SPROUT DISC REFINERS ARE SOLD THAN ANY OTHER MAKE

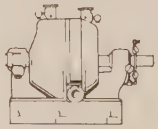


36-1 • REFINERS • 36-2

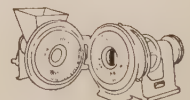


DOUBLE DISC REFINERS





20"-26" • PRESSURIZED REFINERS • 34"-42"



LABORATORY REFINERS

NIAGARA® BRILLIANT BLUE BFL CONC

has an affinity for even-sided whites!

Turn Over

Compare the reverse side of this sheet with [illegible] bright blue-white of the [illegible] Niagara® Brilliant Blue Sidedness is compared to the whiteness of the [illegible]

National® Direct Dye for paper produces non-twosided whites at any pH from 4.0 to 8.0

Many mills have adopted this quality dye, produced domestically only by National Aniline, to improve even-sidedness of their white papers.

Having affinity for longer cellulose fibers, Niagara Brilliant Blue BFL Conc isn't carried off in the white water. It tints wire-side and top-side alike, with no loss of brightness or light fastness. Color costs are often reduced.

With the advent of alkaline sizes, National Brilliant Blue BFL Conc offers another important advantage. It is one of a full range of National Paper Dyes that work well at higher pH. Your National Aniline representative can provide detailed information.

WRITE FOR SAMPLES AND DATA

NATIONAL ANILINE DIVISION
40 RECTOR STREET, NEW YORK 6, N. Y.
Atlanta Boston Charlotte Chicago Dallas Greensboro
Los Angeles Philadelphia Portland, Ore. Providence San Francisco
In Canada: ALLIED CHEMICAL CANADA, LTD.,
1450 City Councillors St., Montreal 2 100 North Queen St., Toronto 18
Distributors throughout the world. For information:
ALLIED CHEMICAL INTERNATIONAL • 40 Rector St., New York 6, N. Y.

Allied Chemical

An example of Avisco Rayons in Industry

What a world of difference Avisco® rayon makes in specialty papers

Rayon fibers work wonders in specialty papers. For these reasons:

Avisco rayon is immaculately clean, white and absorbent. American Viscose offers a wide range of micron diameters and fiber lengths to control, respectively, porosity and tear strength. Bright fibers add luster; dull fibers lend opacity.

The saturating paper people use rayon in their surface sheets for better transparency, cleanliness and freedom from contamination. Food packagers choose Avisco rayon because it is clean and taste-free. Makers of filtration papers welcome the precision porosity possible through close control of micron diameters.

Whatever your product problem, AVC research and development services are ready to help. Write today.

QUICK REPLY COUPON 4-7

Industrial Merchandising Division
American Viscose Corporation
350 Fifth Avenue, New York 1, N.Y.

Please contact me about Avisco Rayons for use in the following application:_____

Name_____

Company_____

Address_____

City_____ Zone____ State_____

AVISCO® RAYON

AMERICAN VISCOSE CORPORATION, 350 Fifth Avenue, New York 1, N. Y.

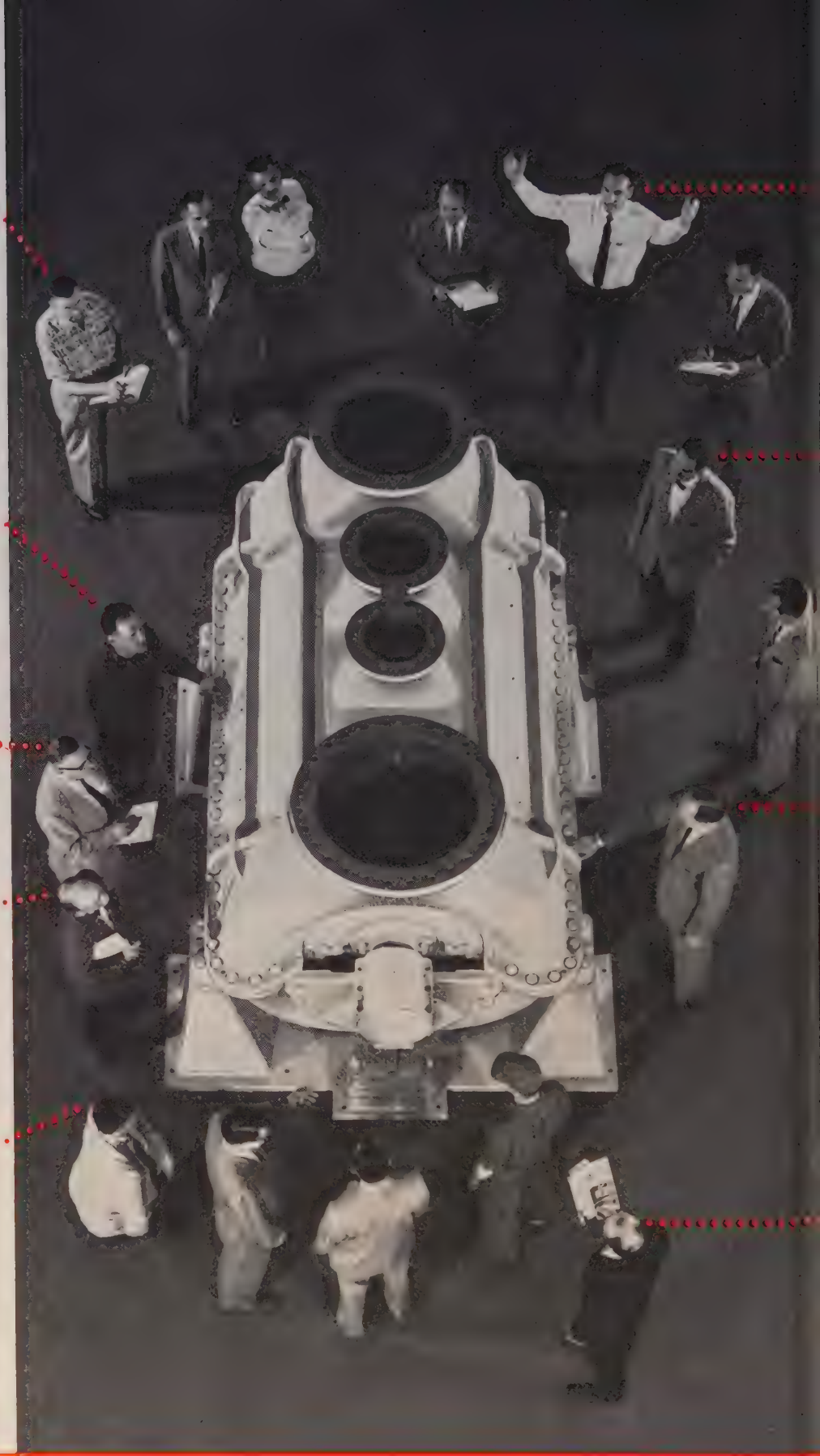
It's the first of its kind ever built in America

It saves up to 25% on horsepower

And 70 to 90% of its power is recovered as hot air for drying

It has reserve capacity, too— no more vacuum pumps to add

Horsepower used is proportional to the actual vacuum capacity you need



Only one unit for an entire paper machine!

The design has been thoroughly proved. You can't beat it for reliability

And it doesn't need any seal water

All the white water is recovered and can be re-used

Automatic control provides vacuum and capacity as required

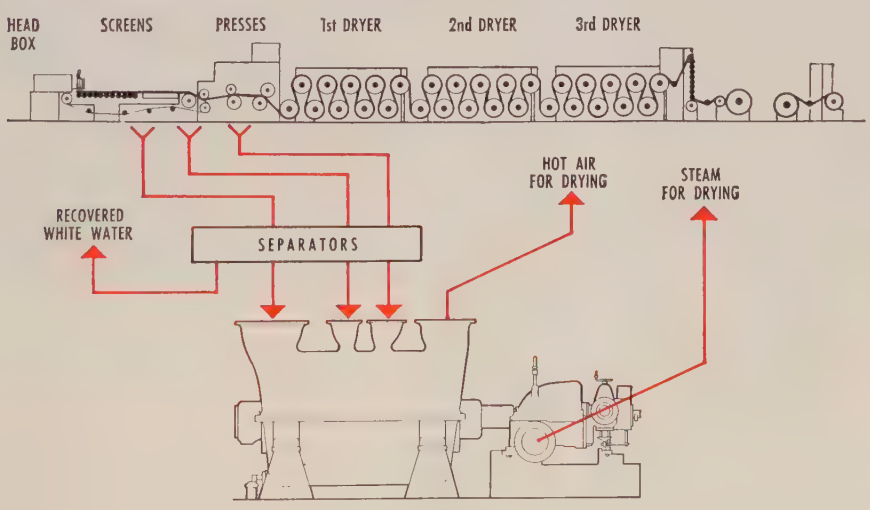
Ingersoll-Rand opens a NEW ERA for the paper industry

...with the FIRST Central Vacuum System for an American Paper Mill

America's first central vacuum system for paper machines is now a reality. This Ingersoll-Rand centrifugal exhauster, with associated separators and controls, constitutes a complete system that meets *all* the vacuum requirements for an entire paper machine. What's more, it also provides an abundant supply of hot air for drying, saving thousands of dollars a year in drying costs.

This first unit, shipped in May, provides a total capacity of more than 36,500 cfm at vacuums of 10″, 15″ and 20″ Hg. Requiring 1,065 bhp, it will do the work that would require 6 individual wet vacuum pumps totaling 1,285 hp, with plenty of reserve capacity to handle extra loads for higher paper machine speeds and changing basis weights. Net saving, 220 hp! Two additional I-R vacuum systems are now being built for two other paper mills.

Ingersoll-Rand can design and build central vacuum systems to meet the exact vacuum and hot-air requirements for any type of paper machine. Ask your I-R engineer for complete information, or write to Ingersoll-Rand, 11 Broadway, New York 4, N. Y.



The I-R Central Vacuum System is an INTEGRAL PART of the paper making process.

Ingersoll-Rand®
11 Broadway, New York 4, N.Y.

E WORLD'S MOST COMPREHENSIVE VACUUM EQUIPMENT EXPERIENCE

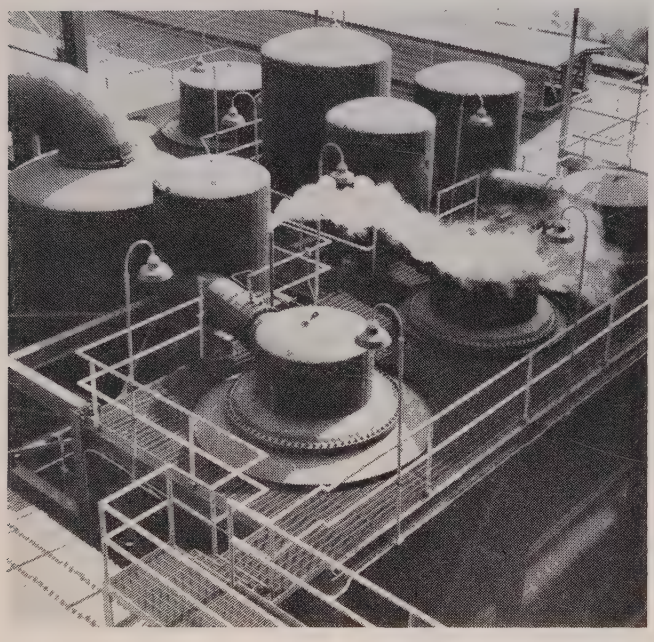
271 A 12

GOSLIN-BIRMINGHAM MANUFACTURING CO., INC.

P. O. BOX 631 • BIRMINGHAM, ALABAMA

BLACK LIQUOR EVAPORATORS

CUSTOM BUILT TO YOUR REQUIREMENTS



Each and every G-B Black Liquor Evaporator is designed to meet a specific application.

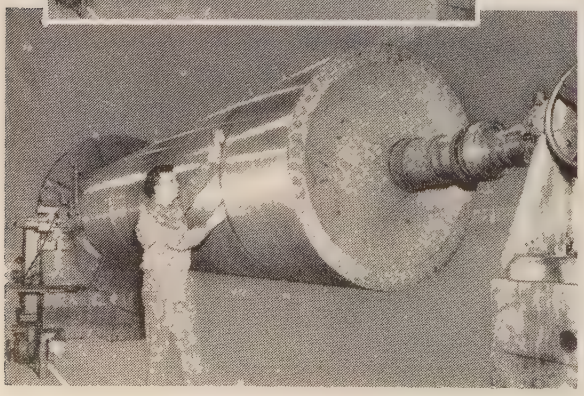
All G-B units are compactly designed to occupy a minimum of floor space. Self supporting units, where outdoor installation is feasible, are designed so that all accessories, walkways, stairs, etc., are supported by the bodies, requiring only a pad and foundation bolts.

B-G has incorporated such desirable features as placing steel tubes on square pitch so the outside tube surface can be easily cleaned, manholes for internal accessibility, built-in lugs for chain falls when lowering the bottom liquor box, davits for removing top domes when retubing, boil out connections, and many others.

REDESIGN AND RENOVATION

G-B offers complete redesign and renovation service for all types o paper mill equipment, such as barking drums, dryer rolls, washers, etc.

The modern G-B foundry and shops can give fast service, often at a freight advantage. G-B's fast renovating service can result in considerable savings over new equipment.



Typical of G-B's renovating services is this 23′ dryer roller. This unit was out of service some time while being stored outside. The unit was machined down to solid metal with a minimum of stock loss, polished and put back into service in short order. Savings to the customer were substantial.

Address inquiries to:

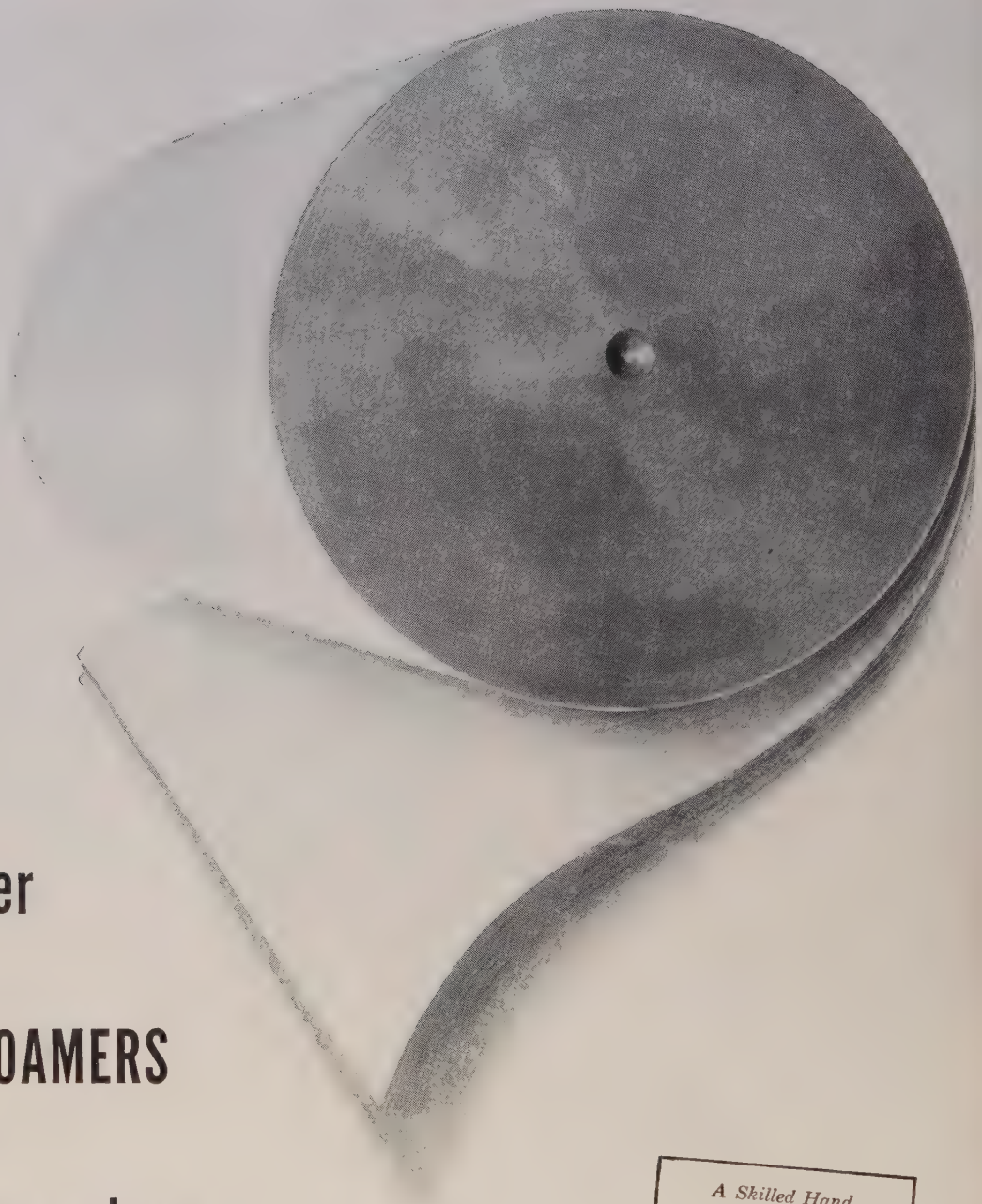
GOSLIN-BIRMINGHAM MANUFACTURING CO., INC.

P. O. BOX 631 • BIRMINGHAM, ALABAMA

The money you can gain by using Accostrength® Resin is no illusion—the savings are substantial. You save by greater use of hardwood fibers. This resin increases the wet web strength—thus minimizing paper breaks in the wet end of the machine, reducing costly downtime. You save, too, because Accostrength improves the drainage on the wire, reduces steam requirements in the dryer—making higher production rates possible. Accostrength also lets you save through increased rosin size efficiency by reducing size usage up to 50% while still maintaining sizing specifications; or by producing a more highly sized sheet with the same amount of rosin size input you use now. Why not try the modern way to produce more paper, better paper, stronger paper—at lower cost with Cyanamid's Accostrength Resin. So call your Cyanamid salesman and get the facts.

CYANAMID

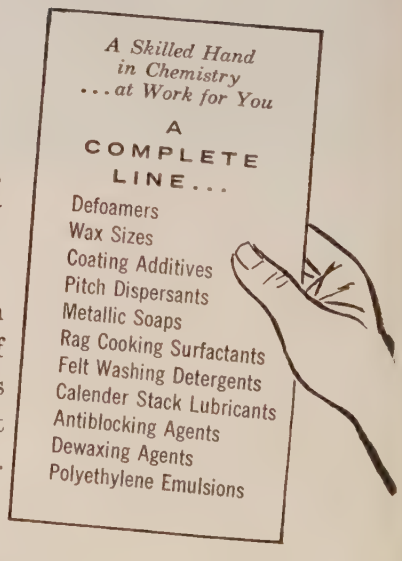
AMERICAN CYANAMID COMPANY • PAPER CHEMICALS DEPARTMENT • 30 Rockefeller Plaza, New York 20, N.Y.



make cleaner paper with NOPCO® DEFOAMERS backed by Nopco know-how

One of the causes of a bad run of paper can be foam. Bubbles that carry fiber, size or color on their surface burst and leave light spots. Those that carry filler or dye leave dark spots. Either way, the sheet won't pass inspection.

Many variables contribute to foam formation. Since each mill has its own distinct foaming problems—because of differences in equipment, type of water, chemicals used and running speeds—it takes a wide range of defoamers to meet them all. Let your Nopco specialist work with you to develop the best system for your conditions. Write for specific information and for literature.



NOPCO CHEMICAL COMPANY

60 Park Place, Newark, N.J.

Plants: Harrison, N.J. • Richmond, Calif. • Cedartown, Ga. • London, Canada • Mexico • France
Manufacturing Licensees Throughout the World

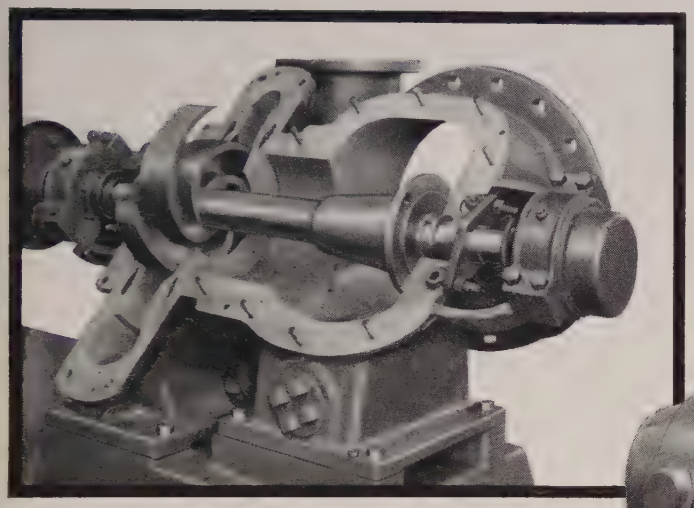
Here's What Users Say about B *HMSS Stock Pumps*

"We have found it to be easily maintained and highly effective in pumping stock to consistencies ranging from 2% to 9 or 10%."

Mason Hinkle
The Mead Corporation

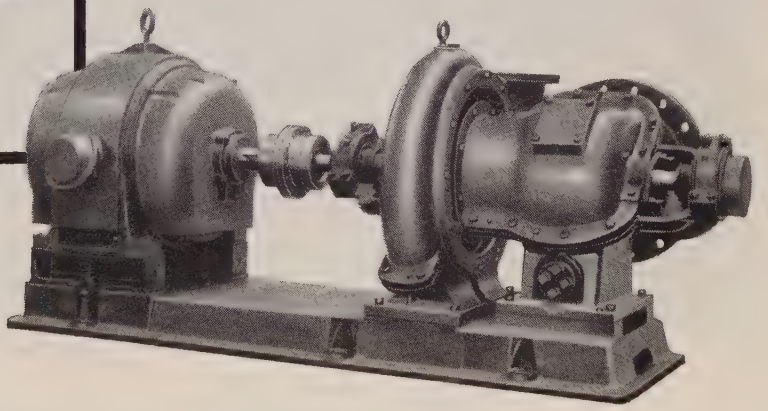
"They are giving us good service."

R. P. McDonald
Fibreboard Paper Products Corp.



"Our men like it very much. We have no hesitation in recommending it as a premium pump."

Victor E. Fishburn
Burgess Cellulose Company



"Our people have nothing but praise for them. The fully diagonally split casing lends itself to quick dismantling and reassembly for repairs when needed. This is very seldom as we have found these pumps to be very dependable and maintenance free."

Potlatch Forests, Inc.

"We buy HMSS pumps because we can depend on your engineering and spare parts service."

D. G. Estebo
The Mead Corporation

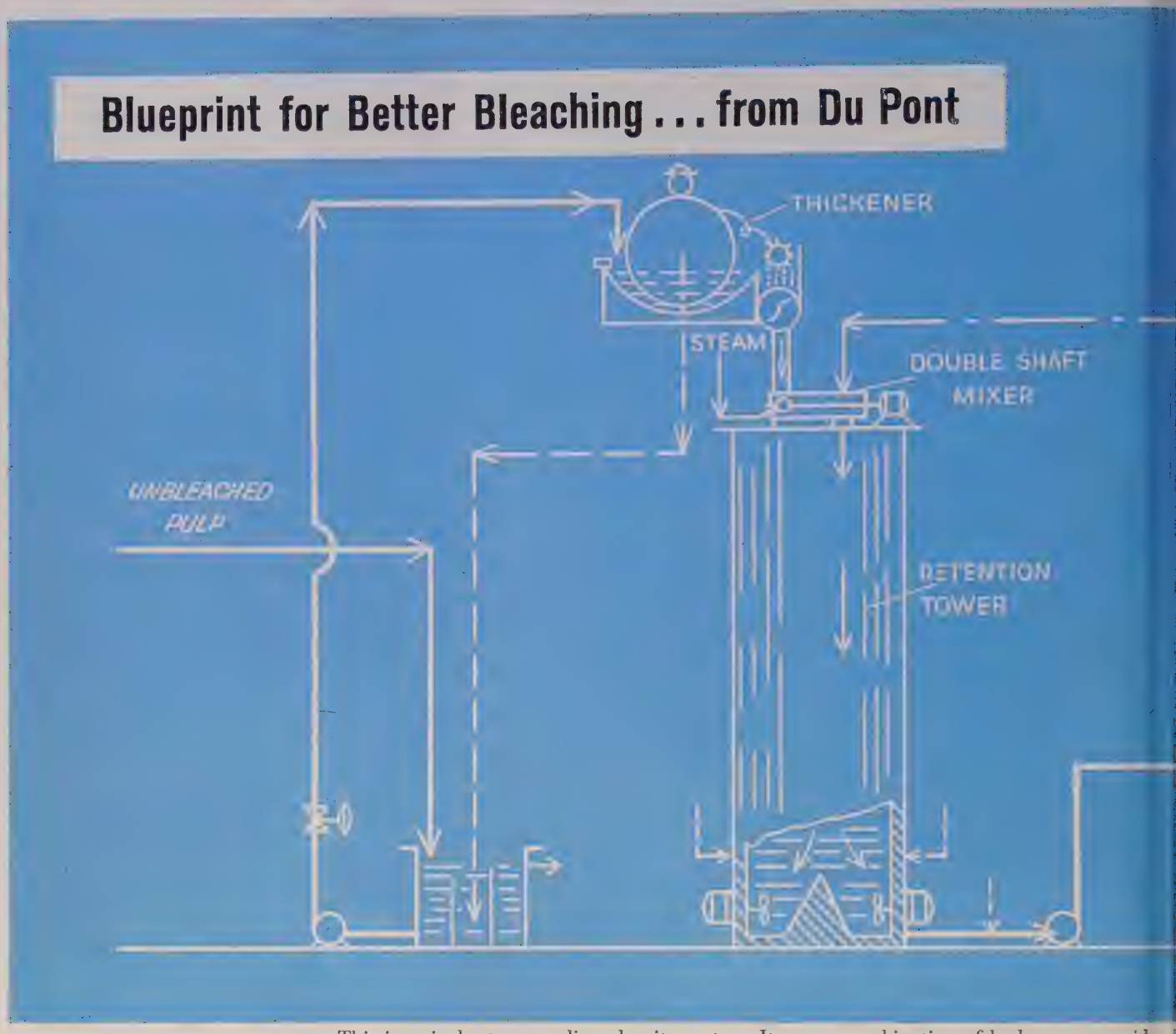
No wonder mill men like it. It's the one centrifugal stock pump that was especially designed for exclusive use in paper and pulp mills.

The HMSS side suction pump is different... has anti-friction bearings, wear plates at each side of the impeller and a separate suction and discharge casing, fully split for quick opening. Full range of sizes ... capacities from 75 to 5000 G.P.M.

SHARTLE DIVISION
Middletown, Ohio
COMPLETE STOCK PREPARATION SYSTEMS

BLACK-CLAWSON

Blueprint for Better Bleaching . . . from Du Pont



This is a single-stage, medium-density system. It uses a combination of hydrogen peroxide

How you can use a combination of Du Pont

To meet today's demand for higher brightness in groundwood paper, Du Pont suggests that you investigate the advantages of a peroxide bleaching system such as the one shown above.

This single-stage, medium-density system uses a combination of hydrogen peroxide and sodium peroxide to make possible groundwood or cold soda pulp brightnesses in the 70-75 brightness range. This means you can produce paper with higher brightness and inherently good printing qualities. Simply by varying the amount of peroxide applied in the above system, the pulp brightness can be readily varied over a wide range as follows:

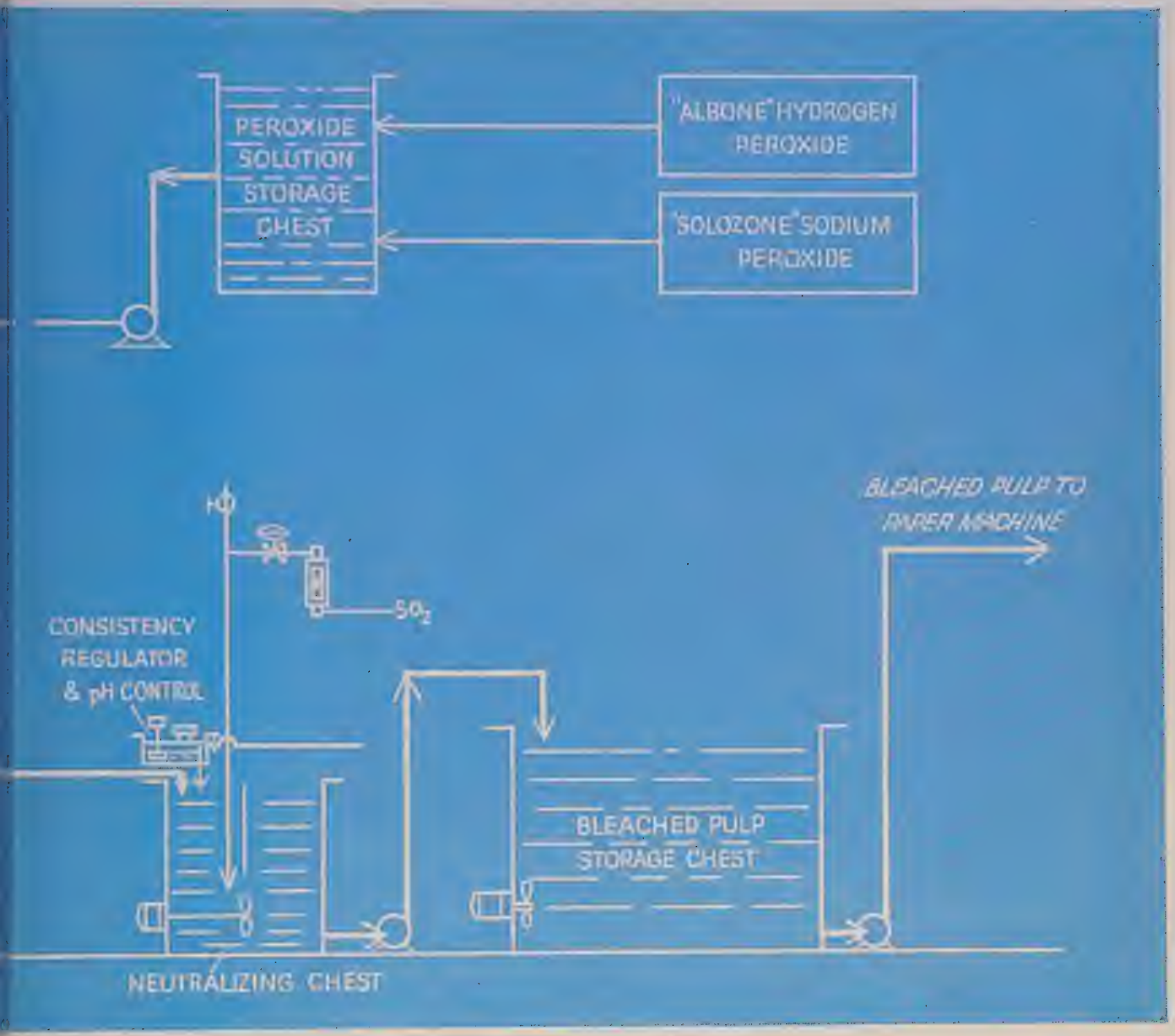
GROUNDWOOD SPECIES	
Spruce-Balsam	(60-63 Unbleached)
Poplar	(63-66 Unbleached)
Southern Pine	(57-59 Unbleached)

CONTACT ONE OF THESE MEN FOR INFORMATION:

Midwest Area
W. L. Liike, Chicago, Ill.—INdependence 3-7250

New York & Boston Area
C. R. Lombard, New York, N. Y.—LOngacre 3-6440

Or call: N. J. Stalter, Wilmington, Del.—PRospect 4-4698



and sodium peroxide to obtain groundwood pulp brightness in the range of 70-75.

Peroxides to increase groundwood brightness

Your Du Pont technical representative will be glad to provide you with further information on peroxide bleaching of all types of pulp... suggest process layouts to fit your present plant operation. He can bring you the benefit of Du Pont's 25 years' experience in providing peroxide pulp bleaching processes—over 50 years as a major producer of both hydrogen and sodium peroxides. Contact your nearest representative listed below, or write: Du Pont, Electrochemicals Department, Wilmington 98, Delaware.

BLEACHED PULP BRIGHTNESS

1% Sodium Peroxide Equivalent	2% Sodium Peroxide Equivalent	3% Sodium Peroxide Equivalent
66-69	70-72	73-77
69-72	73-77	76-80
62-64	66-68	70-71

West Coast Area
P. E. Kiefer, Portland, Oregon—CApital 7-1281

Southern Area
R. W. Hammond, Charlotte, N. C.—FRanklin 5-5561

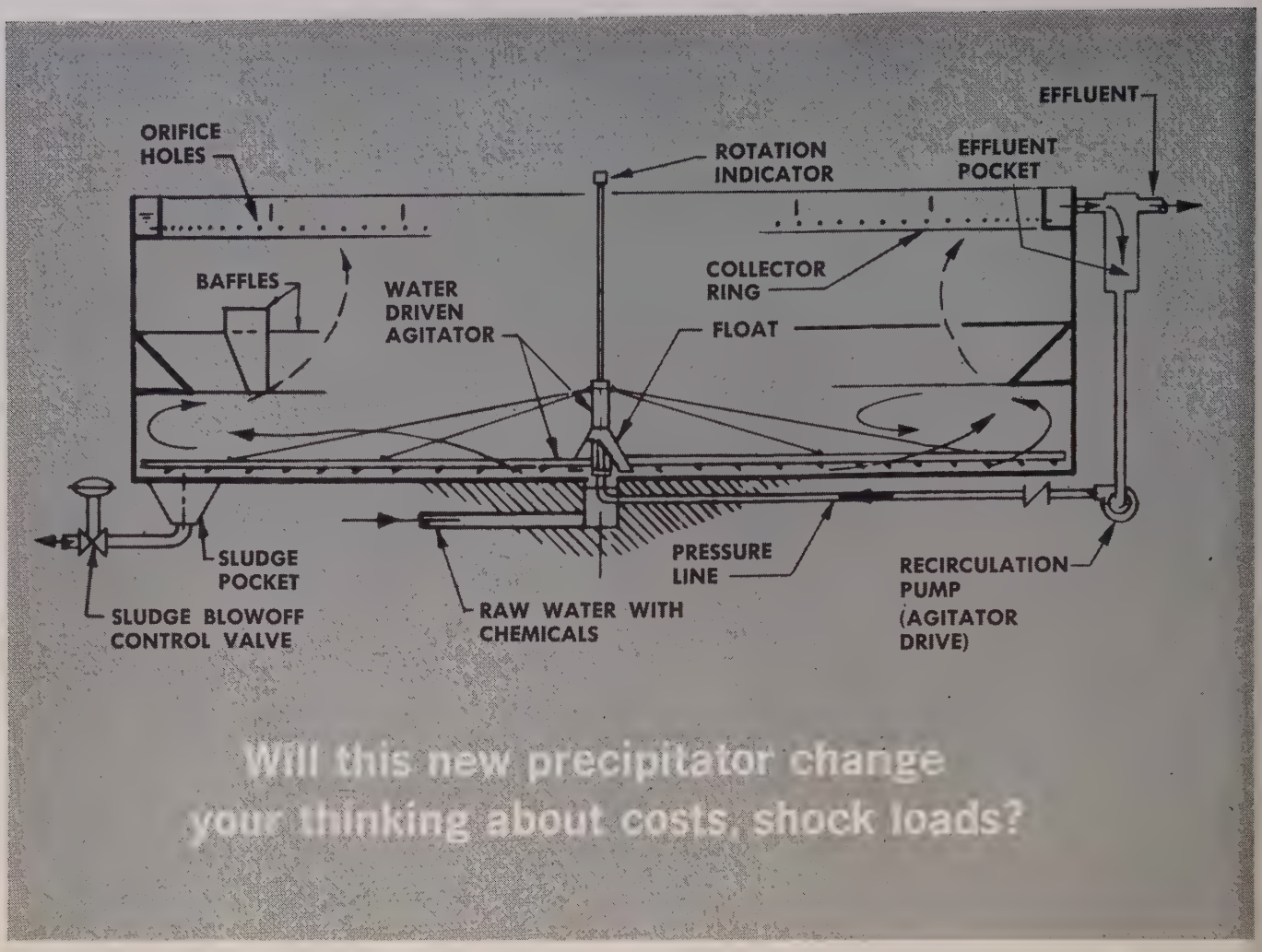
DU PONT PEROXIDES

ALBONE® hydrogen peroxide

DU PONT

SOLOZONE® sodium peroxide

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY



New Permutit Type M Precipitator ... a study in simplicity

Now in operation is this new precipitator for reducing turbidity and color in water.

We call it the Permutit Type M Precipitator. It is a study in simplicity, and because of its low construction and operating costs, it opens up new opportunities to obtain solids-contact clarification at minimum cost.

"Missing" parts: There is no motor-driven agitator on the Permutit Type M Precipitator. No extensive baffling. No center platform. No access walkway. All these have been done away with, because the unit has a new and different agitator system which sweeps away the settled sludge. Rotating agitator arms are supported by a "semi-buoyant" hub (or float) which revolves about a bearing post on the tank floor. Recycled effluent drives the agitator through jet nozzles located at the end of each arm. Smaller jets, spaced along the arms, gently nudge the settled sludge toward a sump at the outer rim of the tank floor.

Briefly, this is how the M unit works: raw water and chemicals are mixed in line and enter at the center of the tank floor beneath the conical rotor float which deflects the fluid mixture radially outward to the walls. A horizontal baffle on the tank wall then reverses the flow back toward the center thus imparting a rolling action to the sludge blanket. This current flow constantly places previously formed sludge in intimate mixture with the raw water immediately as it enters the tank. Clarified, effluent is collected by a flume at the top.

Agitator float and hub assembly.

Sudden water changes: An additional benefit of the Permutit Type M Precipitator is its exceptional ability to handle shock loads.

A case in point: red dye from a paper mill a mile upstream showed up one day in the raw water entering a Permutit Type M Precipitator in use in New England. But the unit went right on putting out an effluent with no significant change in quality.

So much interest has been shown in this new unit that we have reprinted the paper, "A Recent Development in Solids Contact Clarification Design", by E. D. Driscoll of Permutit. We'll be glad to send you a copy.

Write to Permutit Division, Dept. TA-71, 50 West 44th St., New York 36, New York. (In Canada, contact the Permutit Company of Canada, Toronto.)

PFAUDLER PERMUTIT INC.
Specialists in FLUIDICS . . . the science of fluid processes

Marmix®

RESIN & RUBBER LATICES

Here, to meet your needs for resin and rubber latices, is Marbon Chemical's new multi-million dollar research and production facility on the Ohio River. In every way—plant facilities, equipment and personnel—you'll find Marbon the truly modern source for your requirements. Let us prove it—write today, Dept. Y-7.

MARBON CHEMICAL DIVISION **BORG-WARNER**
WASHINGTON WEST VIRGINIA

DICALITE®
TECHNICAL REPORT
DICALITE DEPARTMENT • GREAT LAKES CARBON CORPORATION • 612 SO. FLOWER ST., LOS ANGELES 17, CALIFORNIA

New Dicalite BULK-AID for Paper Products

TRADEMARK

Dicalite BULK-AID is a new development in inorganic fillers, with particle size range and distribution carefully controlled to give maximum bulking characteristics in paperboard and paper products. BULK-AID has the lowest apparent or bulk density of any known mineral filler for papermaking use, thus providing required caliper at lower weights. One example is that of a 40-point groundwood sheet whose weight was reduced from 29.2 lbs/ft^3 to 27.3 lbs/ft^3 by the addition of 10% BULK-AID.

The light weight and bulking characteristics of BULK-AID make it especially suitable for use in paperboard; its high brightness and excellent retention are also of considerable value. BULK-AID lowers the furnish cost and increases pulp mileage in top liners for patent white paperboards. Its brightness and opacity raise the quality of underliners at the same time it extends the furnish.

Dicalite BULK-AID is an amorphous mineral, technically an aluminum silicate, produced from a volcanic mineral known as perlite by a special process developed by Great Lakes Carbon Corporation. BULK-AID is inert, insoluble in water, acid or mild alkalies. It is grit-free, and exhibits no reaction with alum in sizing or with other papermaking chemicals. It is readily dispersed in any furnish, does not cause foam, and will not fill felts.

Among BULK-AID's physical characteristics are these:

Color: White
Average G.E. Brightness: 83

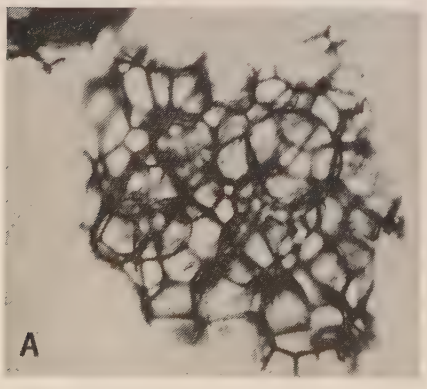
Loose weight: 4½ lbs/ft^3 average

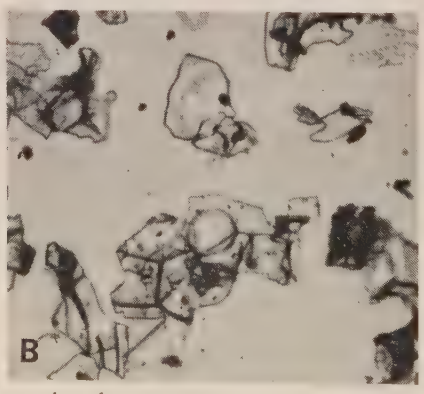
Bulk densities in paperboard: 15 lbs/ft^3 average.

Particle size: 80% less than 10 microns

Extensive testing has shown BULK-AID to be successful in actual paper mill production. Most of these tests were on cylinder machines for paperboard production, but limited tests indicate its value in many slow speed fourdrinier applications.

Your Dicalite engineer will be glad to discuss BULK-AID with you and to advise on possible product applications in your own plant.





When perlite is crushed and then suddenly heated to the proper point in its softening range, it pops like corn into particles like that shown in photomicrograph A, containing a myriad of microscopic sealed cells. The size of the original particle and the application of heat are both important, and are critically controlled. This is the expanded material from which BULK-AID is produced. Controlled milling and air classification by an exclusive Great Lakes Carbon Process are the major steps in making BULK-AID, typical particles of which are shown in photomicrograph B.

© 1961 GREAT LAKES CARBON CORPORATION • LOS ANGELES, CALIF.

Gordon G. Halvorsen

DICALITE'S "MAN ON THE SPOT"

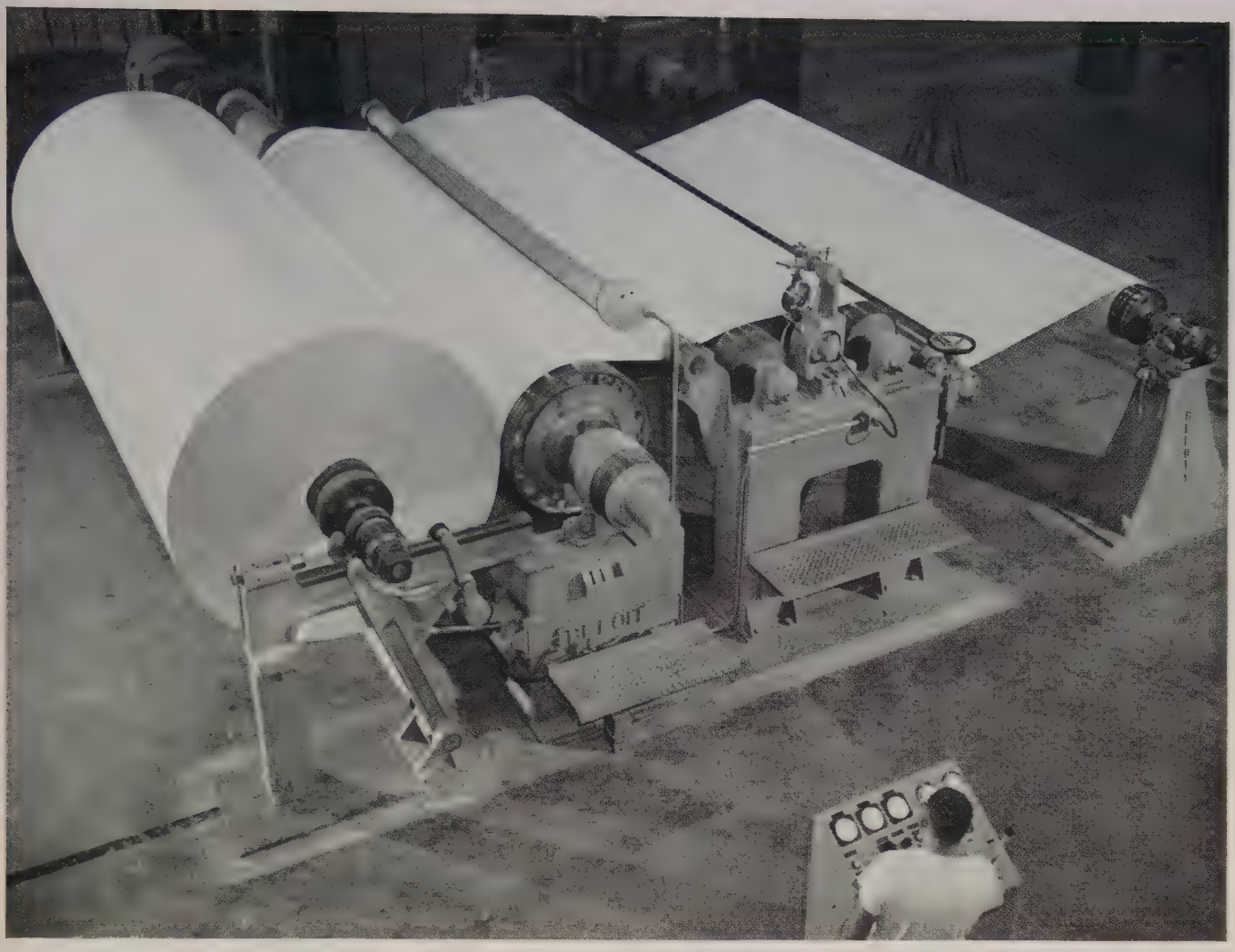
The development of Bulk-Aid, to meet the industry's need for an extremely low density bulking agent, was initiated by Gordon Halvorsen, Product Sales Manager for Dicalite, and he has been closely identified with its tests and product application work from the beginning.

Halvorsen has an extensive background in research and development work, beginning with his graduation from the University of Minnesota with a degree in Chemical Engineering. Prior to joining Great Lakes Carbon in 1940, Gordon had been engaged in technical and laboratory work in the pharmaceutical, corn processing and water treatment fields, and continued his research work in the Dicalite product laboratories for the first 5 years of his association.

Halvorsen is the author of several technical papers, and has contributed to both paper industry and brewing publications. Among his technical society memberships he lists TAPPI, American Society of Sugar Beet Technologists, Master Brewers Association of America, and others in the brewing and drycleaning fields.

NEW DATA SHEET

on Dicalite *BULK-AID* gives more complete information on physical and chemical properties, and on its advantages in papermaking. Write for your copy to Dicalite Dept., 612 So. Flower St., Los Angeles 17, Calif.



J. W. MILLER

Consolidated Water Power & Paper Co., Biron, Wisconsin

Beloit Single Drum Coated Papers Rewinder

The versatile Beloit single drum rewinder is an essential yet economical link between the coater and supercalender. Its mill-engineered design provides a functional arrangement for trimming, splicing, and inspection. High-speed operation paces production on the finishing line. Sheet runs may be alternated to suit specific mill requirements. Look to Beloit Eastern for leadership in finished product processing equipment.

FINISHED PRODUCT PROCESSING EQUIPMENT

Winders • Reclaim Winders • Cutters
Slitters • Sheeters • Supercalenders
Roll Wrappers • Roll Lowering Tables
Roll and Shaft Handling Equipment
Conveyors • Unwind Stands and
Tru-Tension Controls • and other
equipment for the paper and
allied industries.

Member Beloit Group

BELOIT EASTERN CORPORATION
Downingtown, Pennsylvania

Type HH alloy header elbow handles hot SO_2 gas for 15 years

Delivers seven times the service of previous casting at 1800°F

Hot, corrosive SO_2 gas was eating header sections out of sulfur burners every 2 to 2½ years at a sulfite plant operated by one large paper-making company.

Engineers ordered an elbow section cast of type HH* alloy, containing 11 to 14% nickel and 24 to 28% chromium. That was 15 years ago, and the elbow —still in service today—has delivered more than *seven times* the service of previous castings. As a result, engineers at this company have specified type HH alloy replacement sections for their sulfur burners ever since.

Advantages of nickel-alloyed castings. Type HH alloy is one of a family of nickel-containing casting alloys that offers special advantages to the pulp and paper industry. These alloys are easily cast into complex shapes, and are readily available from foundries. By providing superior resistance to high temperatures, corrosion, erosion and caustic and acid environments, these nickel-containing alloys help keep maintenance and parts-replacement costs to a minimum.

Get helpful information on these nickel-containing alloys and find out how they can improve efficiency and cut costs in *your* plant. Write for the comprehensive, 72-page booklet, "Heat Resistant Castings, Corrosion Resistant Castings... Their Engineering Properties and Applications." Ask for booklet A-266.

*Alloy Casting Institute designation

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street INCO New York 5, N. Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

Actual mill runs prove

KELGINS® and KELSIZE S®

ACTUAL MILL RUNS			
MILL	SIZE AND BASIS WEIGHT	SURFACE SIZE FORMULA	GURLEY DENSOMETER SECONDS/100 C.C.
A	BLEACHED BOARDS	CONTROL (USUAL FORMULA)	150
		CONTROL PLUS 0.3% KELGIN	3000—5000
B	17 x 22—11 LBS.	CONTROL (USUAL FORMULA)	14
		CONTROL PLUS 0.2% KELSIZE S	28
C	34 x 22—14 LBS.	CONTROL (USUAL FORMULA)	17
		CONTROL PLUS 1.0% KELGIN XL	59
D	17 x 22—25 LBS.	CONTROL (USUAL FORMULA)	26
		CONTROL PLUS 0.3% KELGIN LV	40
E	34 x 22—32 LBS.	CONTROL (USUAL FORMULA)	400
		CONTROL PLUS 1.5% KELGIN XL	1800

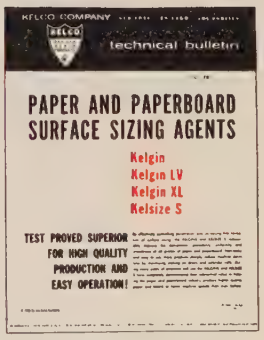
Gurley Densometer, courtesy of W. & L. E. Gurley

INCREASE DENSOMETER TEST

Unmatched, this unique ability of the Kelgins and Kelsize S to raise densometer test. With stock refining reduced, you achieve far higher machine speeds and increased production. Applied at size press as the sole sizing agent or with other sizing, the Kelgins and Kelsize S effectively close up the sheet, substantially raise densometer. Solution make-up is remarkably quick and easy, for the Kelgins and Kelsize S dissolve fast and completely in cold or hot water. Completely non-tacky, the Kelgins and Kelsize S appreciably improve machine speeds and substantially reduce "set-asides".

YOURS ON REQUEST:

Technical Bulletin details latest data on Kelco surface sizing agents including specific solutions to problems of improving densometer, printability, uniformity, smoothness, reduction or machine down time.

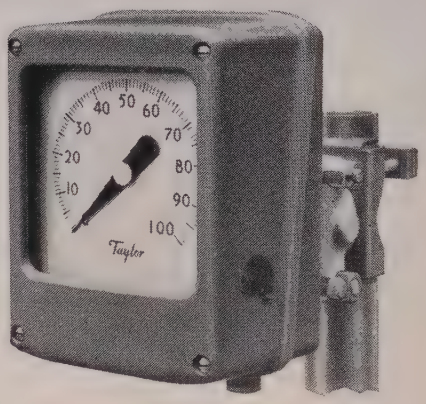


KELSIZE S® KELGIN® KELGIN LV KELGIN XL

products of KELCO COMPANY

A DP TRANSMITTER OF MANY USES!

New Taylor 212T Transmitter is first and foremost a superior DP Transmitter . . .



Indicating model has 11¾" long, 270° concentric scale that can be read up to 35 ft. away.

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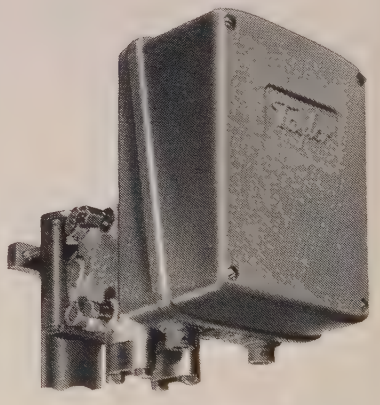

"Blind" model, showing rear mounting and bottom process connections.

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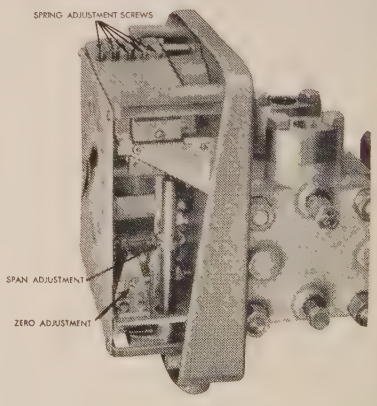

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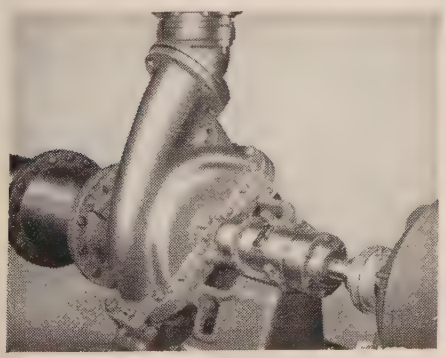
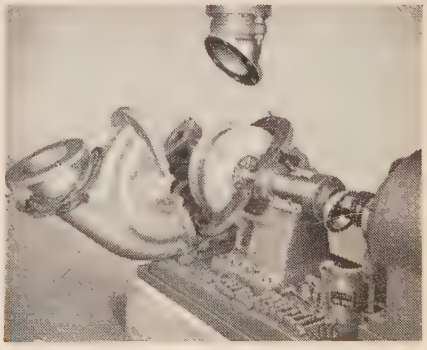


GOULDS PUMPS



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Data on the *successful* Betz approach to microbiological control in pulp and paper mills is contained in Bulletin 592. May we send you a copy?

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VELOCITY CHART FOR IGT PRINTABILITY TESTER

INK USED IPI NO. 6

SPRING TENSION USED [X] A [ ] B

PRINTING VELOCITY, FT./MIN. AT 35 Kg, PRINTING PRESSURE

A TENSION	B TENSION
	100
100	200
200	300
	400
300	500
400	600

DOW LATEX 630 COATING
Picking Velocity: 290 Ft./Min.

COMPETITIVE LATEX COATING
Picking Velocity: 150 Ft./Min.

PROVEN commercially... greater pick resistance with DOW LATEX 630

The velocity chart, left, for IGT Printability Tester provides proof of the greatly superior pick resistance of new Dow Latex 630. Here, laboratory test data are reported on the relative printability of commercially coated papers.

The two strips on the right coated with a competitive latex represent the performance of the "standard" grade. The two strips on the left represent the performance of that grade with Dow Latex 630 replacing the competitive latex in the coating.

In this test, Number 6 ink was used, and "A" spring tension. The test strips show that average pick velocity of strips with the competitive latex coating was 150 ft. per minute. But strips coated with Dow Latex 630 showed an average pick velocity of 290 ft. per minute . . . also note the reduction in bodystock splitting and the "blacker" black of the ink with the Dow Latex 630 coating.

In addition to greater pick resistance, Dow Latex 630 offers exceptional starch compatibility, excellent mechanical stability, and other outstanding advantages. Together, they spell superior printability . . . paper that permits clear, sharp, true-to-life reproduction with a minimum of problems for the pressman. Type reproduction stands out sharp and clear, too, because coatings made with Dow Latex 630 produce a more uniformly smooth printing surface.

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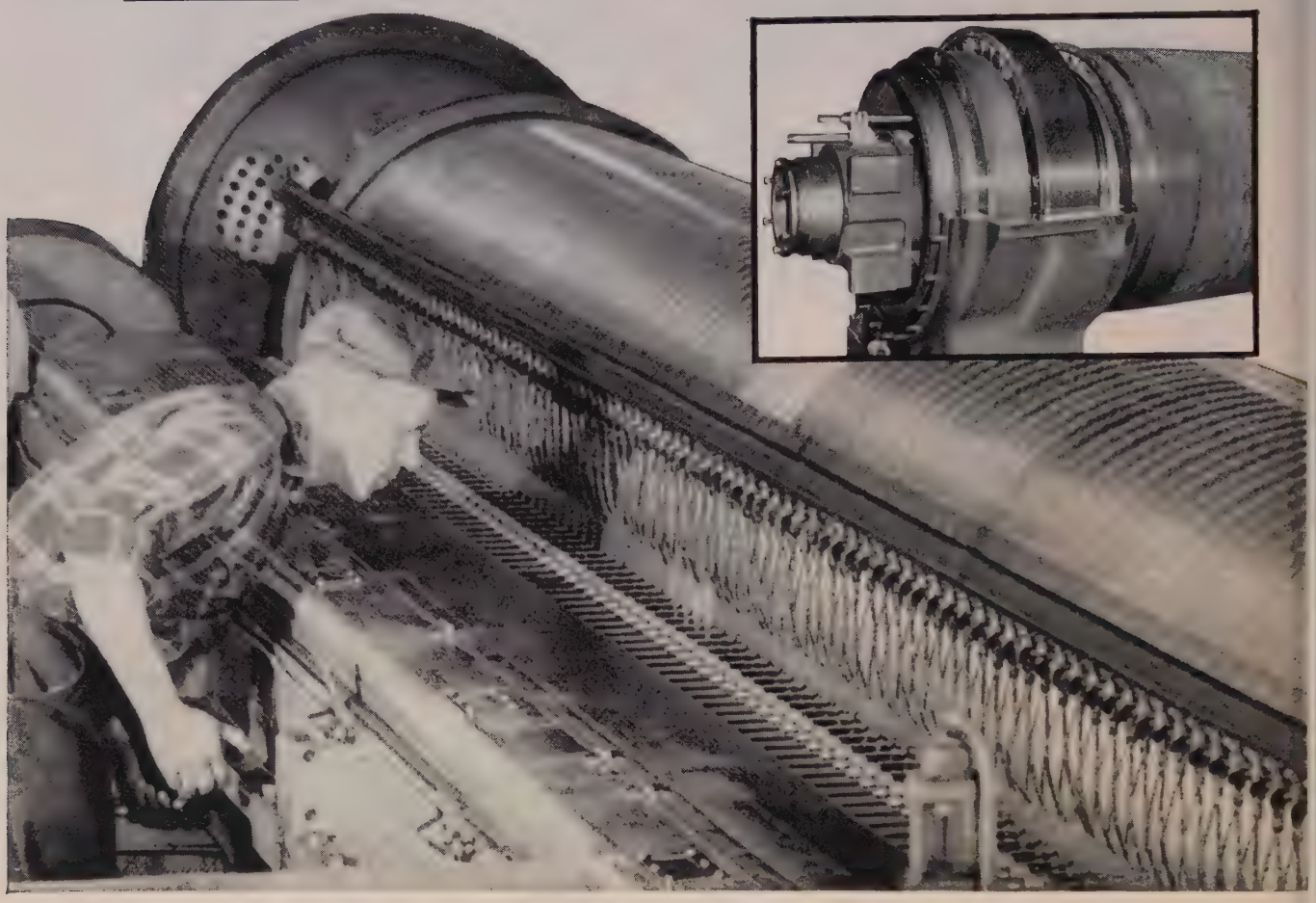

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DESIGN

★ Open-end design for maximum accessibility and easy inspection.

★ Air-loaded suction box tops to ensure uniform wear of deckles and minimum adjustment.

★ Silent drilling pattern for quieter operation.

CONSTRUCTION

★ Forged stainless steel shell for maximum strength, to permit higher line pressures and ensure longer felt life.

★ Suction connection located either front or rear; easy removal of suction boxes without removing head.

★ Large anti-friction bearings for long life, low maintenance.

★ Adjustable suction box widths.

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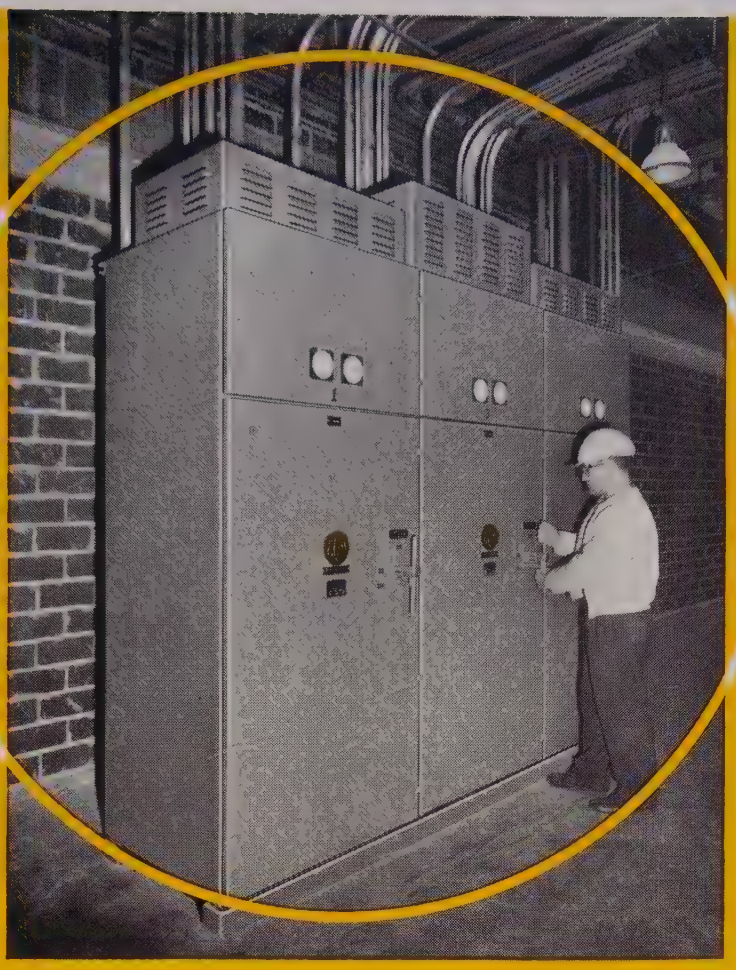

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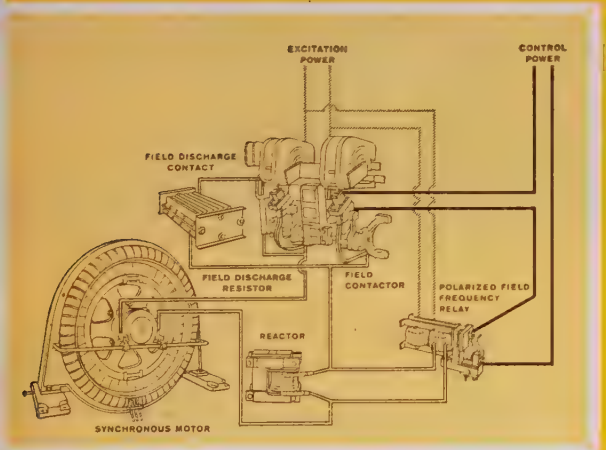

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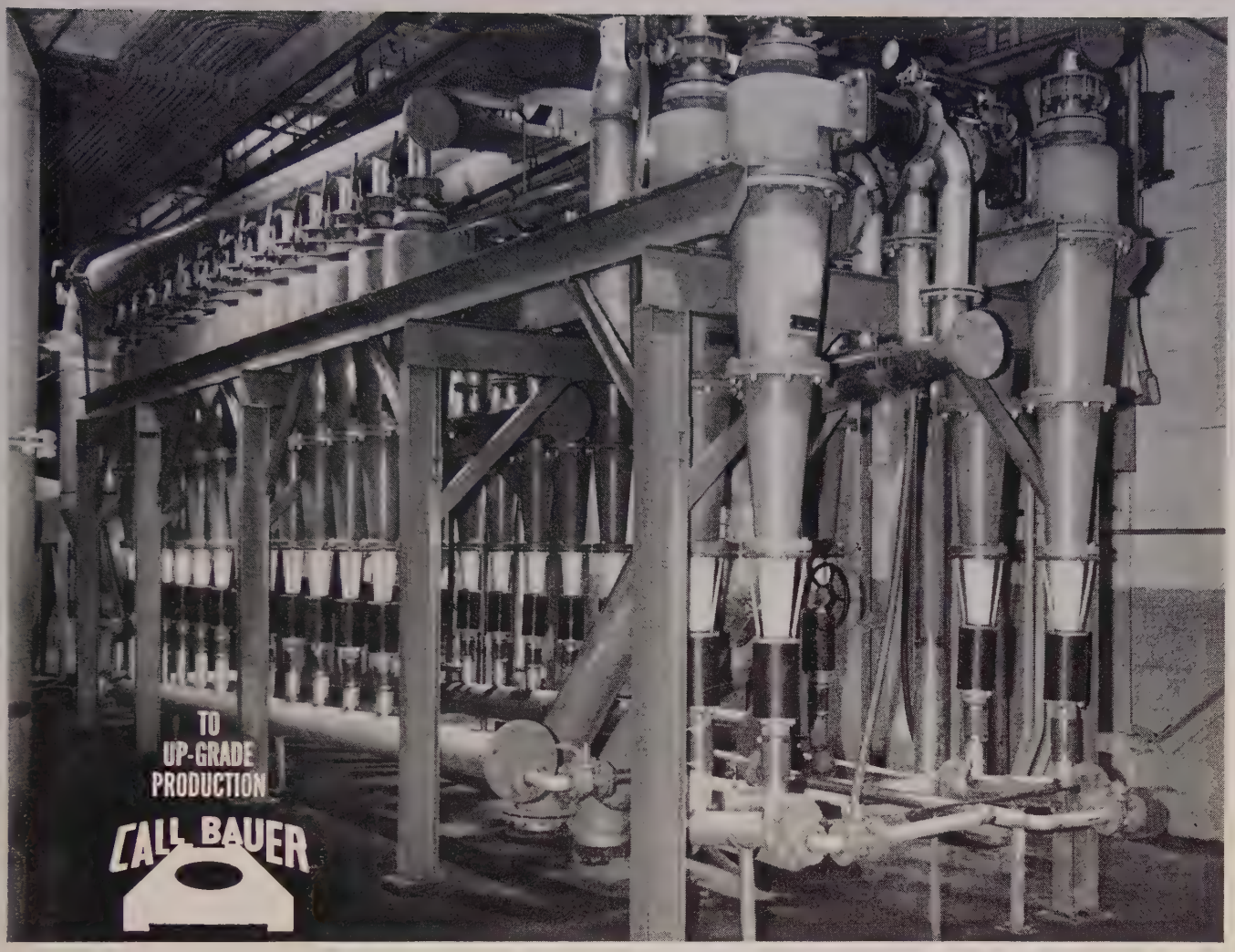

Battery of Bauer No. 623 Centri-Cleaners on No. 4 machine at St. Croix Paper Company. Note long lasting ceramic lower cone nozzles and vacuum rejects-separator system which reduces wear on cleaners in the second and third stages of this modern installation.

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*Idea submitted by Norbert Gossens, Kimberly-Clark Corp., Neenah, Wisconsin
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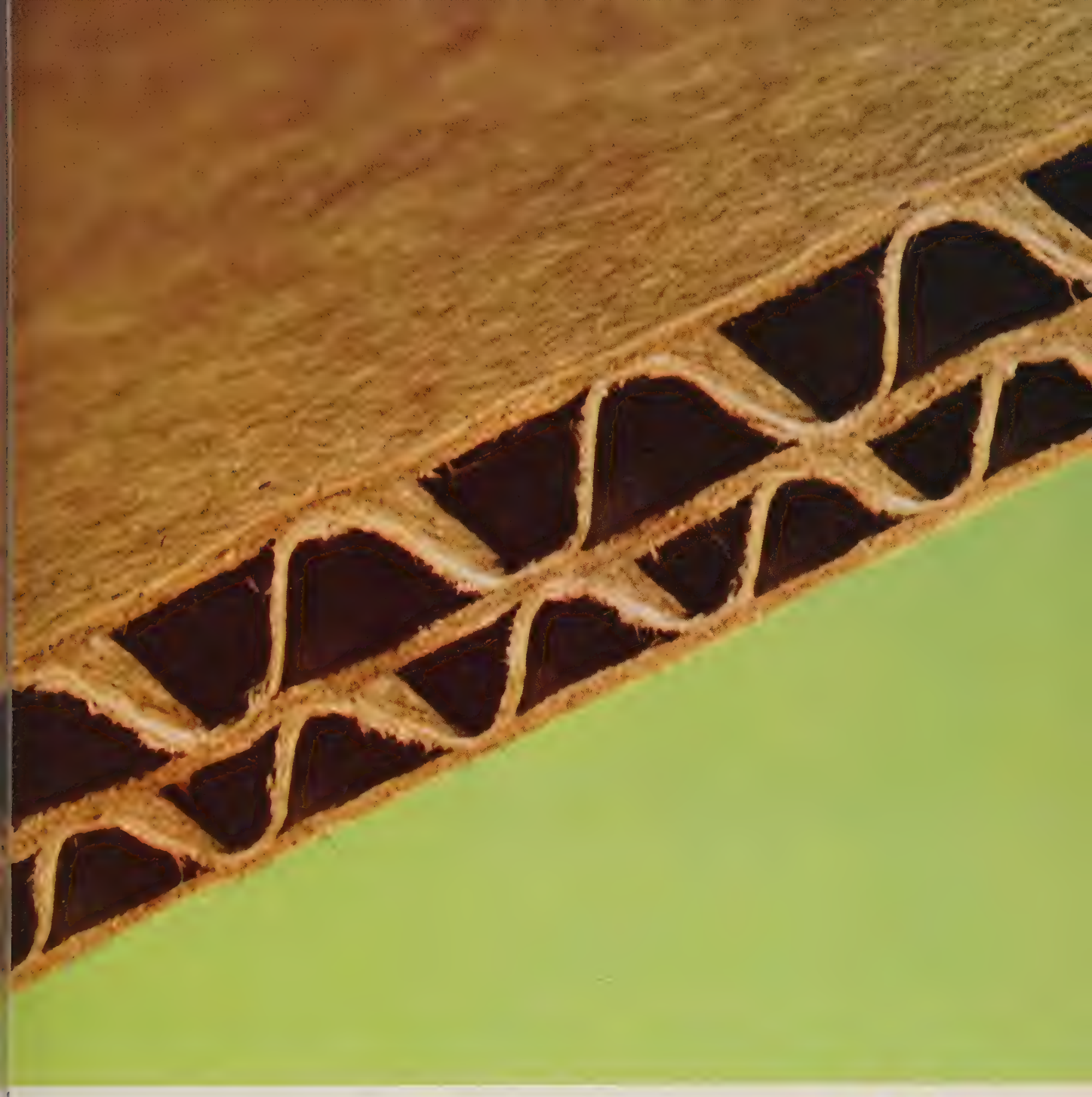

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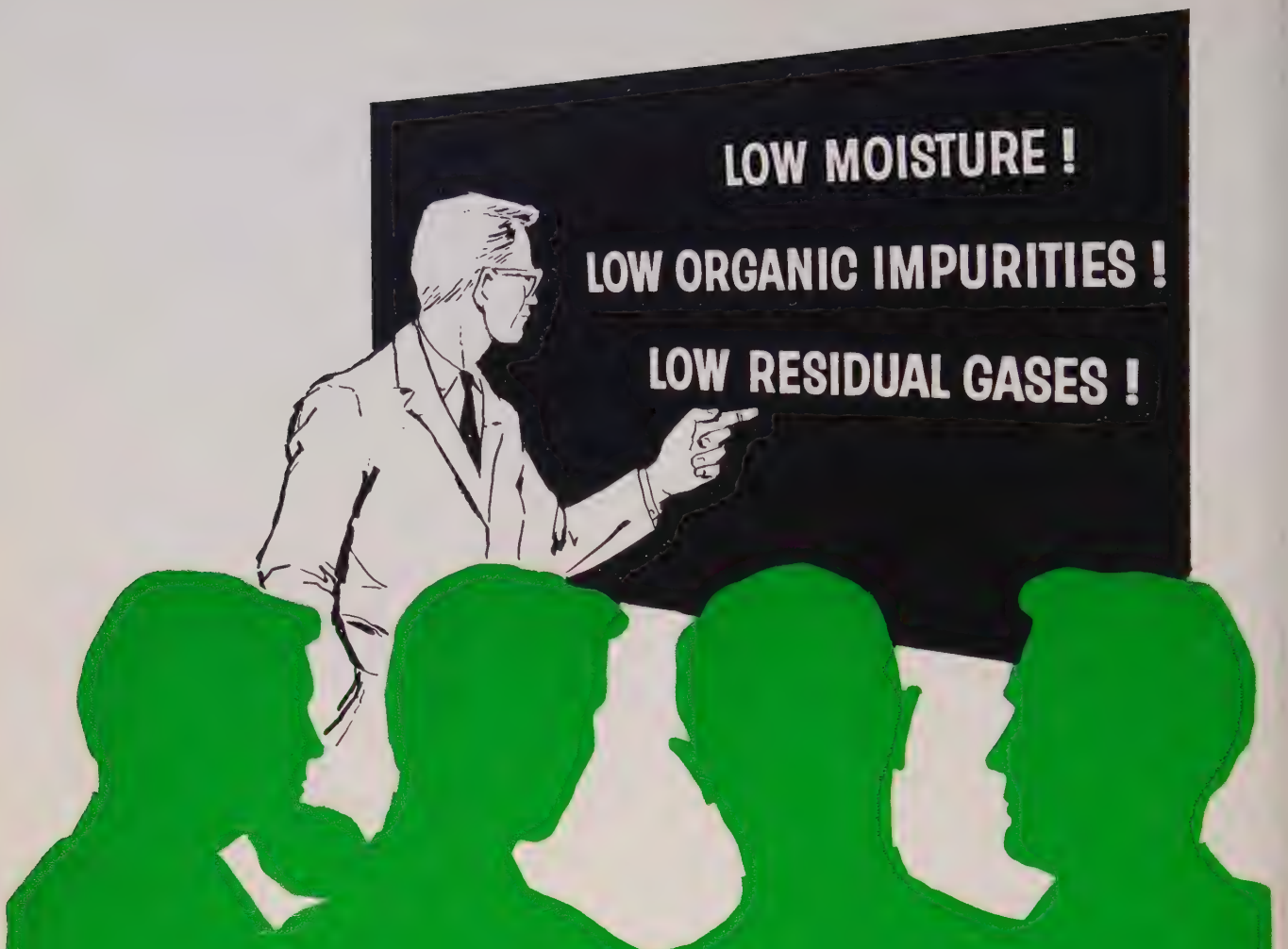

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Improved Defibering and Capacity Increases in Stock Preparation Pulpers

D. H. KOHLHEPP

The need for improved defibering and increased capacity in Hydrapulpers is related to the development of high wet-strength papers and a wide variety of other specially treated paper products. Steps in development of the improved Vokes rotor adaptable to existing pulpers, are summarized, and progressive test results are presented. Reasons are given for final acceptance of a rotor with specially designed vanes to operate in combination with bar-type attrition ring bedplates. Reasons are given for the establishing more exact measurement of degrees of defibering for analyzing pulper performance versus power consumption in a given mill's slushing-refining system. The Black-Clawson defibering index is described. Operation of 18 new rotors in various commercial installations is reported, and horsepower, consistency, defibering efficiency and tonnage capacity comparisons are made between conventional pulpers and Vokes rotor pulpers.

ONE THIRD the gross sales of one of the country's largest paper concerns came this year from entirely new products developed through research—products which were not made by it four years ago. This is typical of the explosive rate in which new paper-base products are being introduced, many containing new bonding and wet-strength agents.

It is safe to say that the materials into which paper is being transformed today by new physical and chemical treatments are generating headaches in many stock preparation departments. That is a subject of current technical interest. That is also, briefly, what is back of the recent improvements in defibering and capacity increases in pulpers such as use of a Vokes rotor.

The Vokes rotor is an improved working mechanism for both bottom-drive Hydrapulpers and side-drive pulpers. It provides a more versatile pulping unit to satisfy the demand to completely defiber the tougher stocks and the demand for higher capacities today. It is ideally suited to despeck wet-strength stocks.

HISTORICAL

High-speed pulping equipment currently employed in stock preparation systems has evolved in the last 20 years. The introduction of the Hydrapulper, in 1939, began a gradual transformation of the beater room, once the scene of hard physical toil, high labor and power costs with which mills have lived since 1750 when the hollander beater first appeared.

Today's modern stock preparation room, by contrast, is automated, completely instrumented, occupies less floor space, requires less manpower and minimum maintenance.

Improvements in pulping since this relatively sterile period ending in 1939, have begun to accelerate in recent years. Indeed, these improvements have been a contributing factor in the 40% increase in output that has taken place in just the last 10 years—from 125 to 179 lb. per man-hour.

It is hardly necessary to point out the many Hydrapulper improvements that have already taken place—in mechanical design of the tub, rotor, and drive, and in operation on batch or continuous pulping. In filler pulping, for example, low-cost handling of mixed wastepapers has been established for separation of good fibers from the litter of material fed into it. Auxiliary equipment such as the junk remover, ragger, rag rope cutter, conveyor, and roll splitter are standard today. Such improvements were necessary to keep pace with the rapid changes in the paper process and in the paper itself.

In 1939, there were very few types of wet-strength and laminated papers to contend with. Many of the pulp and papermaking processes known today were not widespread, nor were the applications of newer coatings, special sizes, and wet strength chemicals. Broke made from the new process or with the use of such new chemicals presents difficult problems in repulping: fan-pump insertion of wet-strength chemicals which set 100% from heat in the drier section, for example.

Today, there are varieties of papers that will not absorb moisture, that will not burn, paper that will stretch, bags that are vaporproof. Book papers are chemically treated to last 400 years. In 1939, wet-strength papers were relatively uncommon, as were containers made of paper laminated to aluminum foil and polyethylene plastic, or the use of paper in wearing apparel; women's dresses, for example. Such progress requires equipment which will economically reclaim papermaking fiber, much of which is high-grade bleached kraft.

DEVELOPMENT OF THE DEFIBERING ROTOR

The above facts called for a new approach to improved defibering and despecking adaptable to existing Hydrapulpers, with either vertical or horizontal drives. The large number of Hydrapulpers in the field today, (more than 2000) necessitated primary consideration in the design of the rotor. Its adaptation to these existing units, where the demand for better defibering or increased tonnage, or both, warrant conversion, as well as its use in new models.

Starting in the summer of 1957, experimental work was begun in the Black-Clawson Stock Preparation Laboratory—then in Fulton, N. Y., now in the new modern research center at Middletown, Ohio. Comparative test work was performed in a 5-ft. Hydrapulper using four basic types of rotors and bedplate combinations.

1. Standard 24-in. open rotor as a standard of comparison

D. H. KOHLHEPP, Project Engineer, The Black-Clawson Co., Shartle Division, Middletown, Ohio.

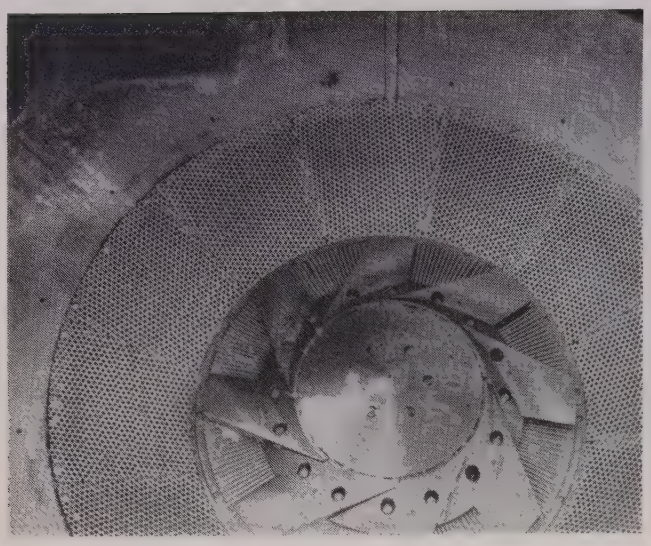


Fig. 1

2. Internal extraction rotor
3. Disk internal extraction rotor
4. Vokes rotor—Hydrofoil vanes and bedplate

The efficiency and practicability of the various rotors was established. The testing gradually narrowed down to the Vokes rotor and an extensive amount of data was compiled using this rotor on various combinations of bedplates, attrition rings, extraction bedplates for discharging the stock through and under the rotor with hole sizes from $^1/_8$ to $^3/_4$ in. diam. at various gap settings. Its performance was evaluated on most commercial grades of pulp and paper from wet lap to hard Kamyr pressed stock, many grades of waste, wet-strength and wet-coated papers, including plastic coated papers. Technical information was obtained on horsepower-per-ton-per-day relationships for various degrees of defibering, consistency, rotor–bedplate gap setting and temperature.

This 5-ft. laboratory Hydrapulper is now constantly used to solve new pulping problems. An interesting example is the separation and recovery of paper fibers and plastic material from polyethylene-coated papers. This was the subject of a separate paper.* Specific analysis of customers wet-strength repulping problems are under constant study with recommendations made

* Dow, John, W., and Felton, A. J. "The pulping and reclaiming of fiber from plastic-coated board and paper," *Tappi* 44, No. 6: 407 (June, 1960).

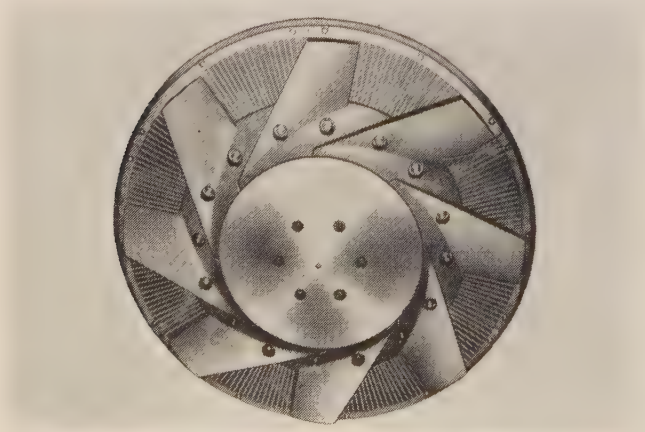


Fig. 2

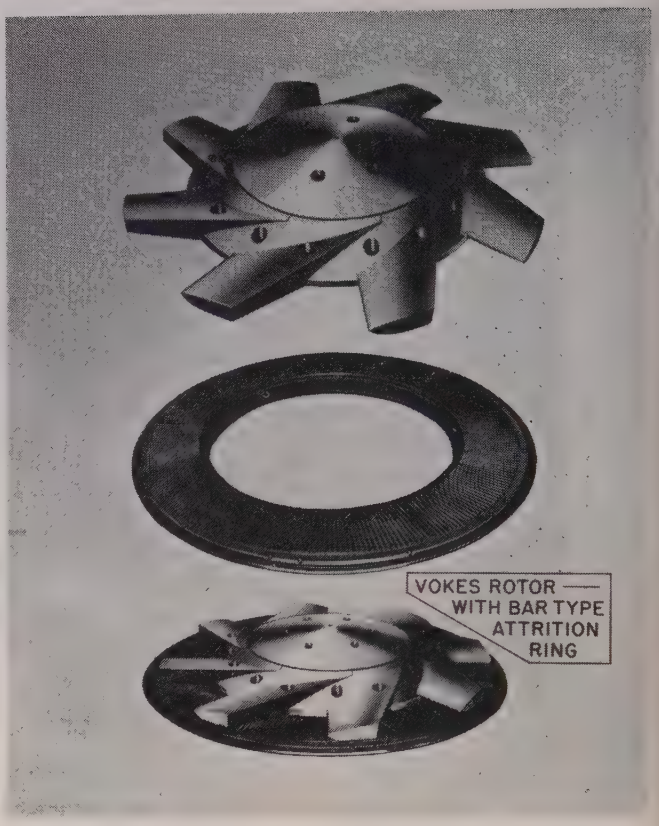


Fig. 3

on chemical and heat requirements as well as on the most economical use of equipment and power.

THE VOKES ROTOR ASSEMBLY

The overall concept is shown in Fig. 1, which illustrates the Vokes rotor applied to a Hydrapulper. The extra-heavy-duty working mechanism located in

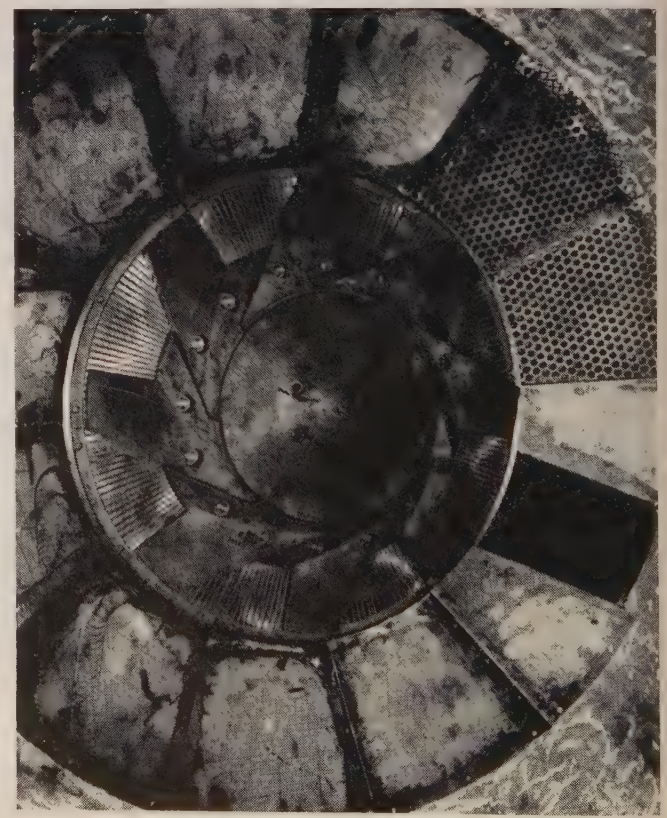


Fig. 4. Vokes rotor with bar-type tatrition ring

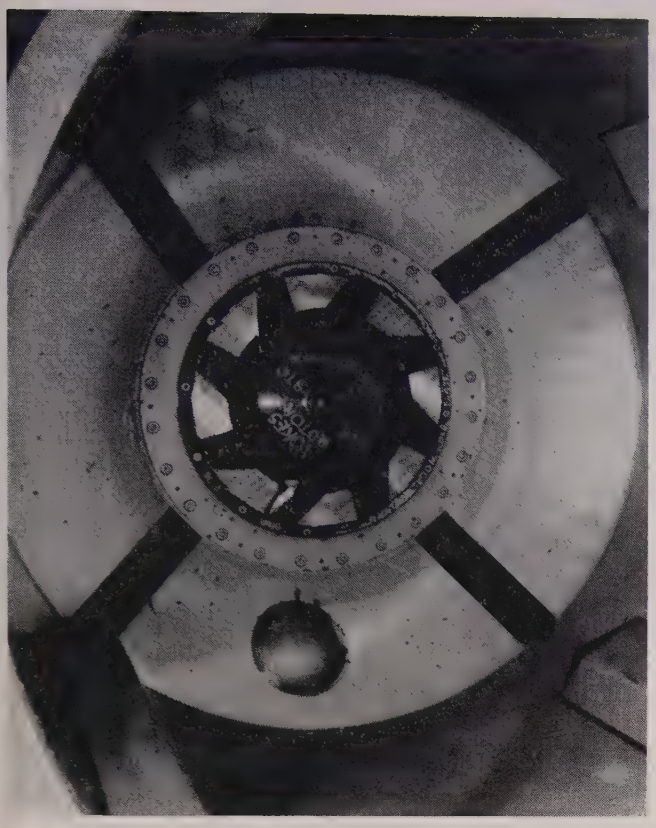


Fig. 5. Underrotor extraction; $\frac{1}{8}$-in. holes in bedplate

the bottom is used in conjunction with four large stationary vanes arranged vertically at equal intervals on the periphery of the tub for uniform turnover of stock into the rotor.

The Vokes rotor assembly itself is illustrated in Fig. 2, which shows the defibering rotor in combination

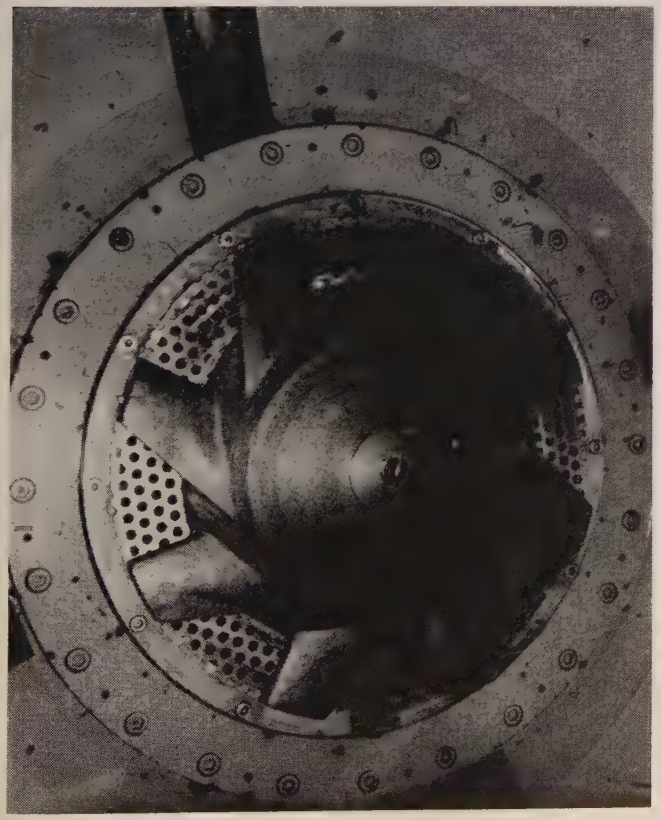


Fig. 6. Underrotor extraction; $\frac{1}{2}$ in. holes

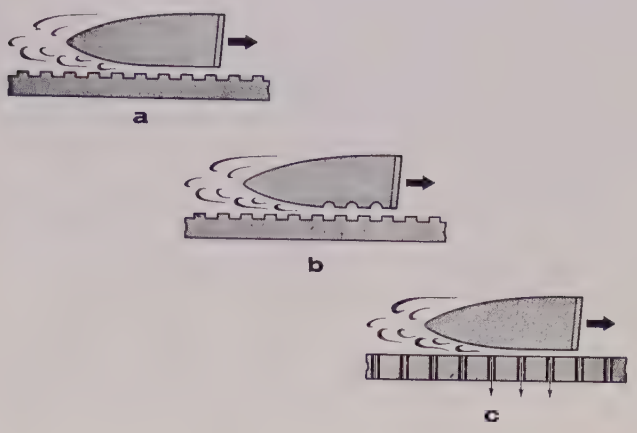


Fig. 7. Typical vane cross-sections

(a) Bar-type attrition ring (b) Same as (a) with vane grooved (c) Underrotor extraction

with bar-type attrition ring bedplates. Figure 3 shows the components of this combination. Figure 4 illustrates the bar-type attrition ring. In Fig. 5 a bedplate with $\frac{1}{8}$-in. perforated holes is shown, for underrotor extraction. Figure 6 shows the same arrangement with $\frac{1}{2}$-in. holes. Minimum clearance is maintained between the rotor and bedplate for most stocks. Perforated bedplates are employed in continuous pulping and extraction units or used in combination batch–continuous pulping. Defibering action with either bar-type or perforated bedplate is comparable. Degree of defibering obtained in continuous pulping is, of course, related to hole size. Cross sections of the rotor vane are shown in Fig. 7.

Figure 7a shows the cross section of the vane used in conjunction with a bar attrition ring. The front leading edge is flat and inverted toward the attrition ring slightly. The top and bottom surfaces of the vane present somewhat of a Hydrofoil appearance as they curve toward the trailing edge. This contour is similar to that used very successfully for the sweeping bars in Selectifier screens. Its action keeps the attritioning ring bars or holes free of stock by creating alternately a positive and negative pressure as it sweeps over the bars. There is no contact between vane and bedplate.

Figure 7b illustrates the same vane, except the underside is grooved for more effective breakup on some stocks. Figure 7c illustrates the vane in conjunction with a perforated extraction bedplate for underrotor extraction.

The leading edge of each vane is provided with an insert of special wear and corrosion resistant material and is replaceable. Where corrosion is not present, the vane ring is made of cast BlaCaloy nodular iron, with the leading edge insert made of hardened stainless alloy of high wear-resistant properties.

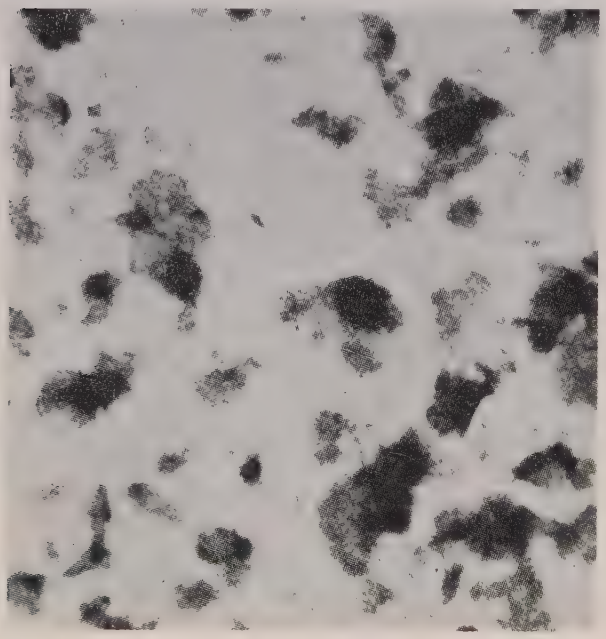
The Vokes rotor and its attritioning surface has the ability to absorb tremendous shock and to efficiently utilize the power required for more complete defibering of unusual paper stocks and pulp furnishes. It maintains circulation at higher consistencies and higher levels. Moreover, increased capacity ratings are now a reality—as much as double on certain stocks—so the result of this development is a more versatile pulping unit.

Application

In order to determine the practicability of the Vokes rotor, an analysis of the mill's slushing-refining system is necessary. What degree of defibering in the pulper is warranted or necessary? To what extent is power presently being wasted? Both product quality and costs are involved in the answer to these questions. In the case of wet-strength papers, it is necessary to establish the degree to which heat and chemicals can be used advantageously without fiber deterioration.

DESIRABILITY OF COMPLETE DEFIBERING

It is an old adage that paper is *made* in the stock preparation department. Probably 75% of the quality in a sheet of paper is dependent upon treatment received in the stock preparation room. Since the Hydrapulper is the first unit in the process to receive the paper stock in many mills, it is important to establish how much it should contribute toward the final product. As a general guide, nearly complete defibering of stock is desirable. All refining and jordaning equipment available today, as well as cleaning equipment, perform their function of fiber development (refining) more effectively if they receive completely defibered stock. They are not designed for efficient removal of fiber lumps and bundles. Moreover, consistency regulators and other instruments, where installed near the Hydrapulper ahead of the refining equipment, can perform more accurately on completely defibered stocks.



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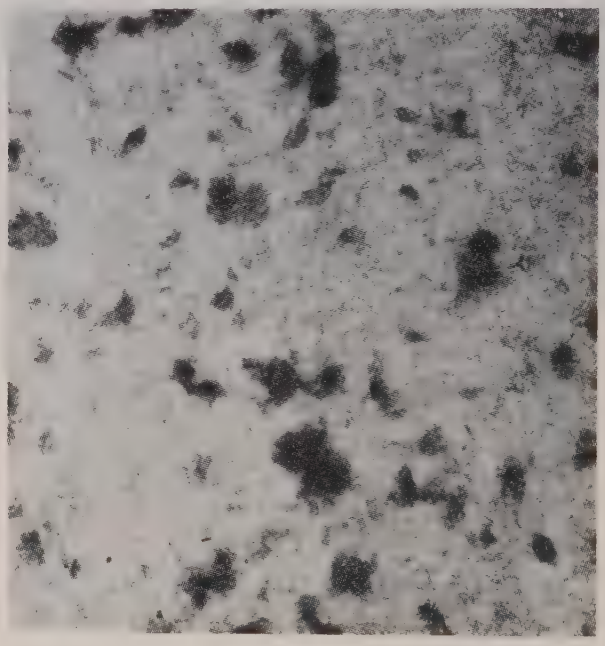

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Fig. 8a. Black-Clawson defibering index

Measuring the Performance

The generally accepted method of measuring the degree of defibering is a visual test of handsheets, such as the comparative defibering index shown in Figs. 8a, b. These are actual size show through photographs of handsheets from the Hydrapulper, showing various degrees of defibering along with their index reference number. They progress in degree of defibering from barely slushed stock (index 10) to competely defibered stock having an index number of 100. By comparing actual handsheets from the pulper with these standards, it is possible to determine the capabilities of the pulping unit and its adequacy with respect to the rest of the equipment following it. Is it performing well enough or are too many good fiber bundles or knots interfering with proper refining? These answers can only be supplied by the use of this tool as a guide. Obviously, each mill must provide its own answer based on its own particular requirement.

For all practical purposes, the 70 to 100 range in the defibering index may be considered as completely defibered on most stocks, exclusive of wet strength, etc. By the time this stock reaches the refining stage, the few remaining specks will have been dispersed by hydraulic action in the pumps, chest, and piping.

There are some mills where the pulper must still be considered predominantly a slushing unit, and a defibering index of 10 the desired goal. An example would be production of fine specialty papers where slushed stock is taken directly from the pulper to a beater.

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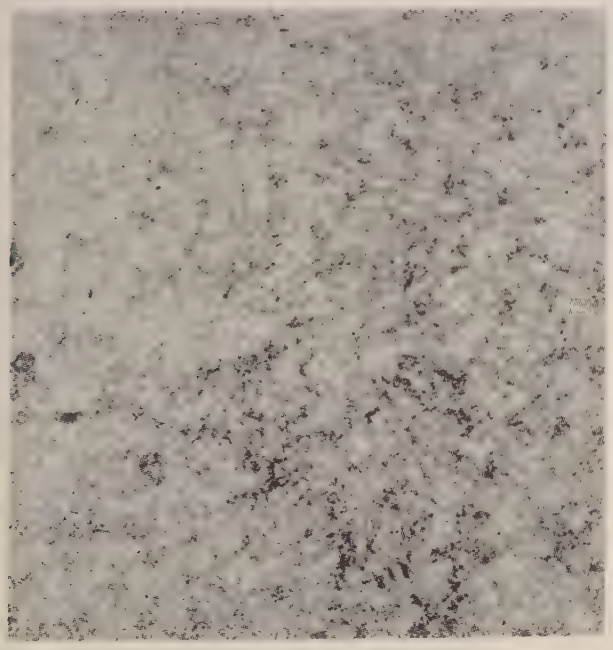

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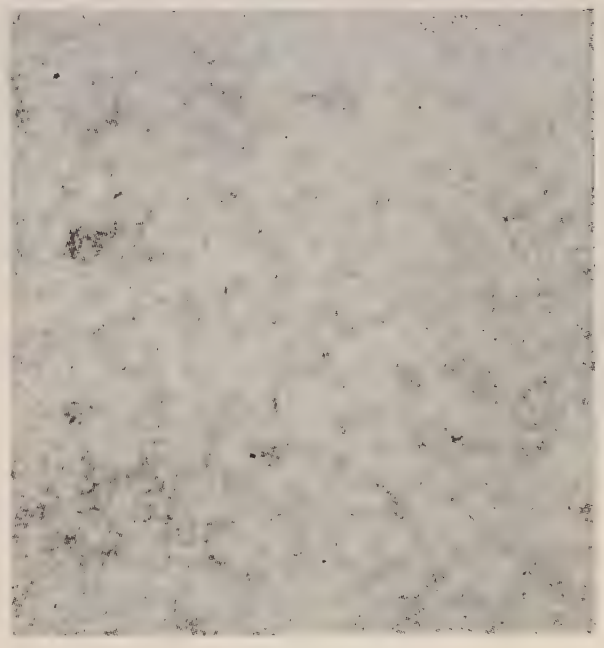

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Fig. 8b. Black-Clawson defibering index

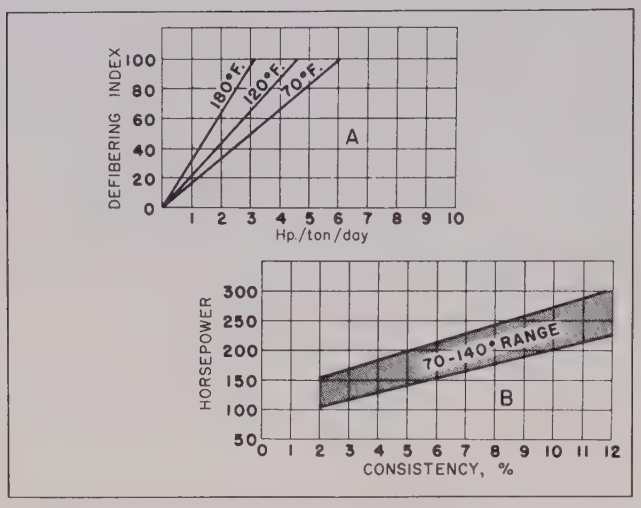
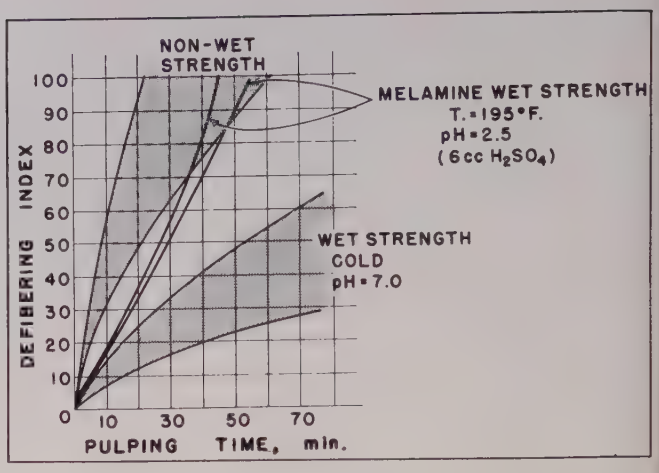


Fig. 9. Variables affecting defibering and power



Vokes rotor defibering index vs. time

Fig. 11. Effect of chemical treatment and heat on defibering index and pulping time.

Effect of Heat on Defibering

Figure 9a shows horsepower-per-ton-per-day requirements of a typical furnish for various degrees of defibering and temperatures.

Effect of Consistency on Horsepower

Figure 9b shows the relationship between power required by the rotor for a given gap setting and consistency. Close gap setting will raise these curves, demand more power. Open gap setting has the opposite effect. Gap setting can vary from 0.010 to 0.120 in. and is changed only to compensate for wear. In the bottom-drive pulpers, adjustment of rotors 72 in. and larger is by means of shims underneath the rotor vanes. Smaller single-piece rotors are provided with adjusting screws. Side drive units may be adjusted automatically or manually.

RECLAMATION OF WET-STRENGTH PAPERS IN THE VOKES ROTOR HYDRAPULPER

Initial slushing of wet-strength paper in the Hydrapulper at room temperature and pH 7 is readily accomplished. However, as the particle size decreases, it becomes more difficult to defiber. The practical defibering index may be reached in the 20 to 40 range, with diminishing returns after this initial slushing.

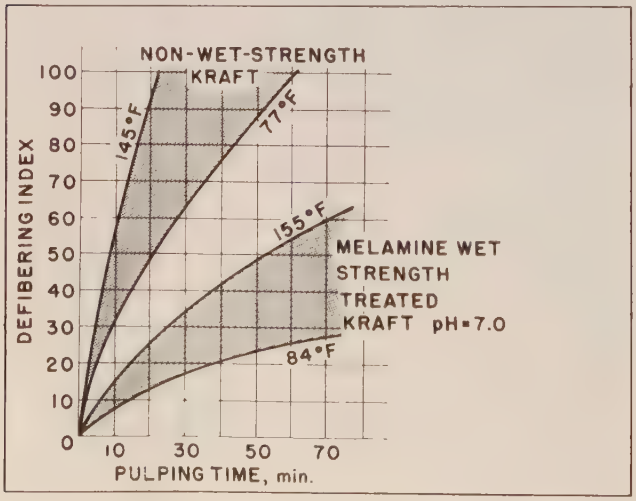


Fig. 10. Vokes rotor defibering index vs. time

In most cases, complete defibering without the aid of heat and chemical treatment is considered uneconomical.

Many wet-strength papers such as melamine type, if chemically treated with alum or sulfuric acid to a pH of 2.5 to 3.5 and pulped hot in the range 160 to 180°F., will handle the same as the basic non-wet-strength fiber. That is, a bleached kraft, wet-strength treated paper can be readily defibered to 100 defibering index in about the same time and with the same power requirements as basic untreated bleached kraft fiber, but only if heated and chemically treated to the proper degree.

In the case of under-the-machine broke pulpers, where it is necessary to get the broke in and out of the pulper quickly, consideration is given to slushing, say, 10 to 20 defibering index, extracting from the pulper in this condition and further chemical treatment and fiber debonding being handled in other pieces of equipment, such as mild re-cooking in a continuous digester and final de specking in the breaker trap or disk refiner.

Figures 10, 11 and 12 illustrate defibering index and pulping time relationships for a typical paper before and after wet-strength treatment, in this case melamine wet-strength. Defibering characteristics at a given temperature range is shown, all at pH 7. Note the

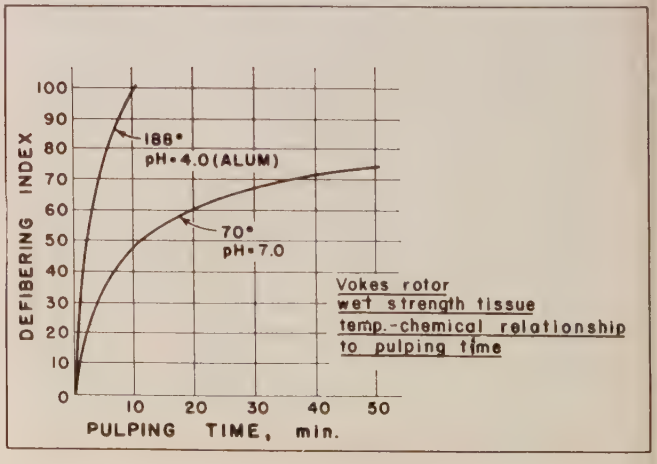


Fig. 12. A comparison of the pulping of wet strength tissue with and without addition of chemicals and heat

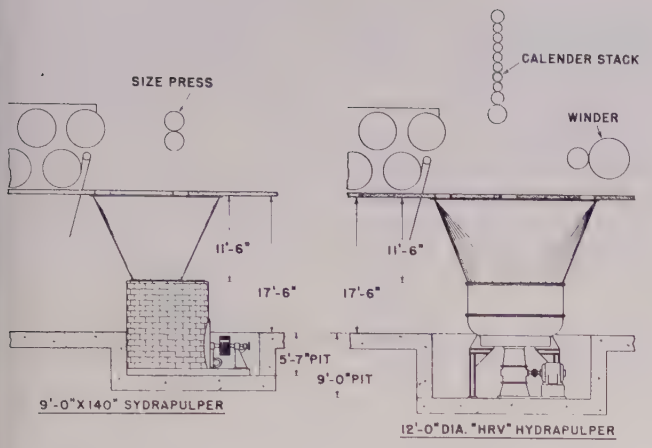


Fig. 13. Broke pulper headroom requirements

impracticability of complete defibering without chemical treatment.

BROKE PULPERS

Ideally, broke is most efficiently handled directly under the dry end of the paper machine through various transverse slots in the floor. A pulper with low head room is usually needed in order to eliminate the necessity for deep pits under the machine. For example, in Fig. 13, a conventional bottom-rotor Hydrapulper has an overall height of 15 ft. plus an allowance of at least 10 to 12 ft. for a guiding chute to bring the broke sheet from the slots into the tub, and space for conveyors may be required. With the Vokes rotor on a side drive or Sydrapulper, the same tonnage can be handled in a pulper 11 ft. 7 in. high. Allowing the same clearance between the top of the tub and underside of the machine floor, this provides for a savings in pit depth of approximately 3 ft. 5 in. Moreover, the oval configuration of the Sydrapulper lends itself to the handling of a wide sheet directly off the machine. Figure 14 shows a broke arrangement with conveyor. This is another development directly related to the Vokes rotor and its ability to provide increased circulation. Figure 15 illustrates a typical Sydrapulper.

MAINTENANCE

We do not anticipate any increased maintenance on this type of rotor as against the conventional open type on either batch or clean stock continuous pulping. As noted previously, we have not as yet evaluated the pulper in handling of wastepaper but this is being planned and we will shortly install this type of rotor in a system of this nature.

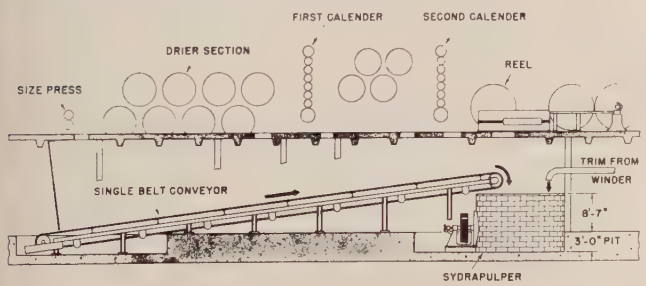


Fig. 14. Broke Sydrapulper with conveyor

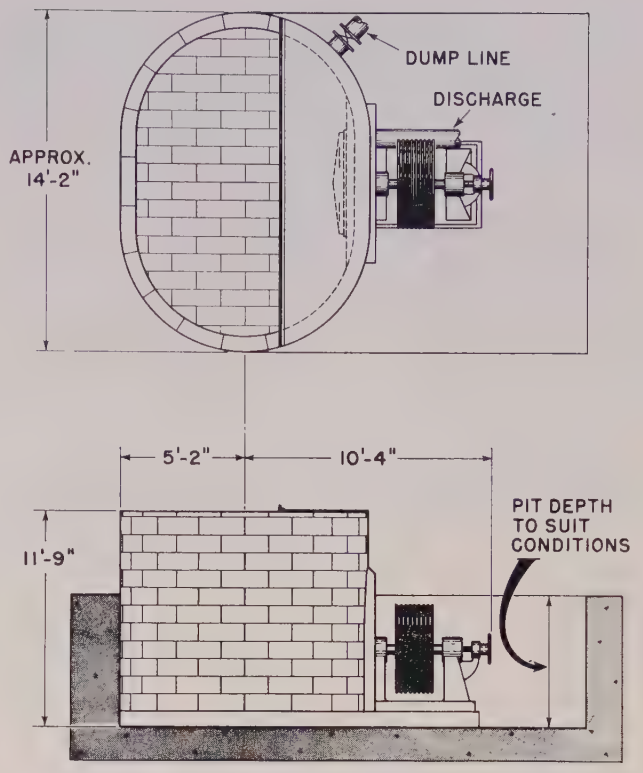


Fig. 15. Typical 12-ft. Sydrapulper

COMMERCIAL INSTALLATIONS

The physical proportions of the laboratory Hydrapulper have been maintained in the new commercial-size Vokes rotor Hydrapulpers in service now. At the time of this writing, there are 18 commercial installations, including conversions, in the field of both bottom-rotor types and Sydrapulper, or side-drive types. They include sizes from 8 to 18 ft. in diameter with up to 400 hp. connected. Both batch and continuous pulping systems are in operation.

These pulpers are installed on the following types of stocks:

(1) Bleach kraft
(2) Unbleached kraft
(3) Bleached sulfite
(4) Waste news
(5) Polyethylene-coated separation
(6) Waste corrugated
(7) Dirty waste corrugated
(8) Magazine broke
(9) Wet-strength broke and waste
(10) Laminated paper separation

Table I. Performance Comparison of Vokes Rotor and Conventional Open Rotor 14 ft. Hydrapulper; Bleached Sulfite Furnished

	Vokes rotor	*Conventional rotor*
Diameter of rotor, in.	67	72
Horsepower	350	200
Consistency, %	6	6
Batch size, lb.	4500	3000
Tons/day	300	100

They are on installations furnishing cylinder machines and fourdriniers. Table I compares the capacity performance of a Vokes rotor in a 14 ft. Hydrapulper

and a conventional open rotor on bleached sulfite furnish. Note the relationships between horsepower and tons per day. Of course, to handle 300 tons per day in a 14-ft. Hydrapulper on a batch basis requires automatic loading equipment and fast dumping with little or no restrictions.

CONCLUSIONS

Today's pulping, repulping, and reclaiming requirements have dictated the need for new improved pulping equipment. The Vokes rotor Hydrapulper and Vokes rotor Sydrapulper have anticipated and satisfied this need.

Proper staging of pulping, cleaning, and fiber development in the stock-preparation room can result in improved efficiency. Feasibility studies on the advantages of more flexible pulping units in relation to refining and jordaning will point the way to better quality and lower power costs.

Reclaimation of wet-strength papers, both broke, cuttings and waste, as well as plastic laminated and coated papers, is being accomplished with resulting economies.

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Irreversible Insolubilization of Casein by Dialdehyde Starch

F. B. WEAKLEY, C. L. MEHLTRETTER, and C. E. RIST

Effects of pH and concentration on cross-linking of casein by dialdehyde starch (DAS) in aqueous borax dispersions were investigated. Varying ratios of DAS-to-casein gave insoluble products differing in composition from one another. Maximum combining capacity of polymeric DAS was found to be 25 g. per 100 g. of casein. Viscosity stability of DAS-casein dispersions was achieved by appropriate combinations of reagents under slightly acidic conditions. Rapid reaction and gelation occurred at pH > 7. The results obtained indicate promise for DAS as an effective and practical insolubilizing agent for proteins. An anticipated extension of the present study is the application of DAS-casein systems to pigment-coating of paper.

The effect of aldehydes, and in particular of formaldehyde, on aqueous protein dispersions has been the subject of numerous investigations of both a theoretical and a practical nature (*1, 2*). More recently the low-molecular-weight dialdehydes, such as glyoxal and glutaraldehyde, have been made to react with proteins (*3, 5*) and have found some measure of success as tanning agents in leather manufacture (*6, 7*).

Dialdehyde starch (DAS), a polymeric dialdehyde produced commercially by periodic acid oxidation of starch (*9, 10*), also gave interesting results in collagen and gelatin studies (*6, 8, 11, 12*). However, little information is available on its reactions with other proteins. The peculiar dialdehyde structure of DAS, its solid nature, high molecular weight, and low acute toxicity (*10*) are favorable practical characteristics that prompted investigation of its reactions with casein to determine whether improved water-resistant coatings for paper could be prepared.

The reactions of bifunctional reagents with proteins generally involve both intra- and intermolecular bonding. With DAS, cross-linking is expected to occur by reaction of its carbonyl groups with the amino groups of casein to form polymer networks having considerably different properties from their constituent parts. The polymeric nature of DAS, however, introduces a new factor into such protein reactions that may be of significance to the general application of proteins in industrial processes.

In this paper results are reported of investigations on the insolubilization of casein by reaction with suitable dispersions of DAS. The development of increasing viscosity with extent of cross-linking was followed over a range of pH and concentration to determine the relative rates of reaction of the reagents at 25°C. and to establish practical limits of viscosity for use of the reaction mixtures in paper-coating studies.

EXPERIMENTAL

DAS was prepared by periodic acid oxidation of cornstarch to the extent of 95% of theory (*9*). This highly polymeric dialdehyde was completely dispersed in water in 10% concentration by addition of 10% of its dry weight of borax and agitating and heating at 73°C. for approximately 15 min.

The casein used was a purified high-nitrogen product obtained from Nutritional Biochemicals Corp.,* Cleveland 28, Ohio. Dispersion was achieved by stirring casein in water for 15 min. prior to addition of 10% of its dry weight of borax with continued agitation for 30 min. at room temperature.

In most experiments DAS and casein dispersions were combined to produce a homogeneous mixture and, after adjustment of pH, were allowed to react at 25°C. Rapid reaction occurred in the pH range 6.8 to 8, and was markedly influenced by concentration of the reagents. Higher alkalinity caused excessive degradation of DAS (*13*) and an increase in color formation. Under acidic conditions the reactivity was appreciably lowered.

Complex Formation

The maximum amount of DAS that will combine with casein was determined by reacting borax dispersions of these reactants in the high weight ratio of 6:1 at pH 7.1 and 25°C. Concentration of casein was limited to 0.8% in this case to avoid an extremely viscous reaction mixture. Under these conditions maximum

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* Mention of firm names or trade products does not imply that they are endorsed or recommended by the Department of Agriculture over other firms or similar products not mentioned.

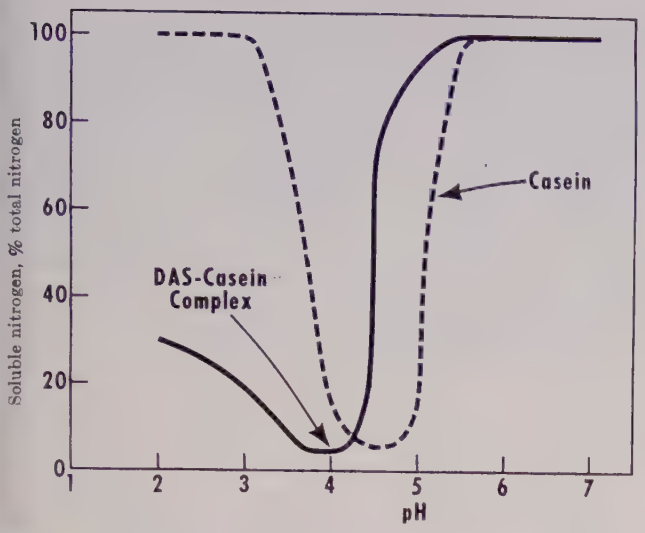

Fig. 1. Behavior of dialdehyde starch–casein (1:1) and casein dispersions in borax upon acidification

complex formation of casein and DAS was found to occur in 1 to 3 hr. The quantity of unreacted casein at 0, 1, 3, and 5 hr. was determined by acidifying aliquots of the reaction mixture to pH 4.6, the isoelectric point of casein.

In a separate trial the DAS-casein complex was precipitated at pH 3.7 after 3 hr. of reaction. The product that was isolated contained approximately 95% of the added casein in chemical combination with DAS. The isolation procedure entailed filtering, washing free of acid with water and finally with 80% ethanol, and drying *in vacuo* at room temperature. An aqueous borax extract of the dry product contained neither free casein nor complex. The light-colored complex had a nitrogen content of 12.54%. From this analysis its composition was calculated to be 20% DAS and 80% casein and indicated that 100 g. of casein were bound by 25 g. of DAS, the highest combining capacity of DAS for this protein. Extensive acid hydrolysis of the complex in the presence of *p*-nitrophenylhydrazine gave a nearly quantitative analysis for combined DAS present (*14*). The cross-linked casein is practically insoluble in dilute alkali and acid, a completely different effect than with casein and DAS alone. Because of this irreversible insolubility, DAS-treated casein dispersions have potential value for use as water-resistant coatings for paper.

A study was made of this reaction at lower ratios of DAS-to-protein to define better practical conditions for the quantitative irreversible insolubilization of casein.

Figure 1 illustrates the pH-precipitation behavior of a DAS-casein mixture after 1 hr. of reaction at 25°C. and pH 7.1. The weight ratio of the reagents was 1:1, and their concentration in the solution was approximately 0.8%. After 15 min., the pH decreased from 7.1 to 6.9; therefore dilute alkali was added to readjust the pH to 7.1 for the remainder of the reaction period. Acidification of the reaction mixture to pH 3.7 precipitated nearly quantitatively a reaction product composed of 15% DAS and 85% casein. Some solubility of the precipitate was observed on further addition of hydrochloric acid to pH 2. The product did not dissolve in a sodium hydroxide solution at pH 9. In contrast, a casein control was nearly all precipitated at its isoelectric point and redissolved upon further acidification to pH 3. Casein was also completely dissolved at pH 9. Nitrogen analyses of the solutions were made after centrifugation at the various pH levels investigated.

Table I. Reaction of Dialdehyde Starch (DAS) with Casein at pH 7.1

Wt. ratio, DAS:casein	*Casein concn., %*	*Reaction time, hr.*	*Isolated complex yield,[a] %*	*Composition of complex, % DAS*	*Casein*
6:1	0.8	3	95	20	80
1:1	0.8	1	95	15	85
1:10	7.0	2	90	10	90

[a] Yield based on casein used.

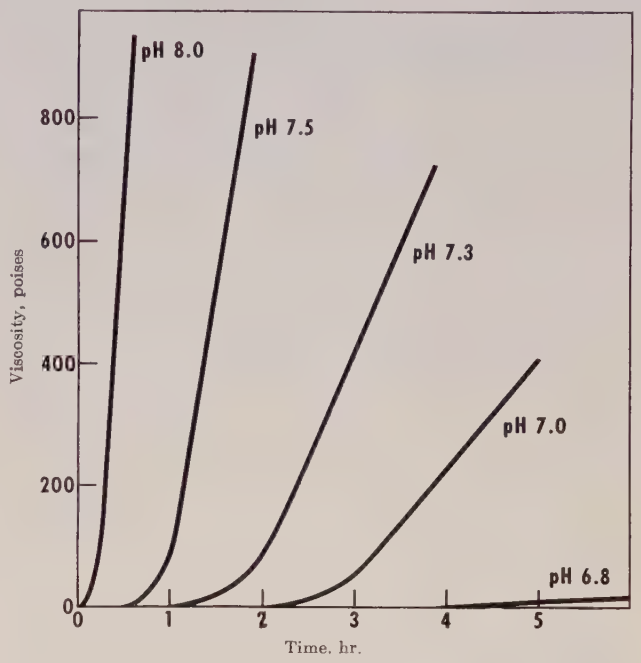

Fig. 2. pH-Viscosity relationship for a 1:10 dialdehyde starch–casein dispersion

The composition of the complex can be varied and is dependent upon the concentration and the ratio of the reagents used in the reaction (Table I). The cross-linked complex obtained from a 7% casein dispersion after reaction with 0.7% DAS (a 10:1 ratio) for 2 hr. at pH 7.1 was composed of 90% casein and 10% DAS. The viscous, final reaction mixture was diluted with water before precipitation of the product at pH 3.7. A ratio of DAS to casein of 1:20 gave a complex that was contaminated with a large quantity of unreacted casein.

Effect of pH on Viscosity

An important property of casein in water-resistant paper-coating applications is its viscosity behavior in aqueous dispersion in the presence of insolubilizing agents. Viscosity development results from reactivity of the functional groups of proteins with cross-linking agents and is greatly influenced by the pH of the reaction mixture. An increase of pH in the alkaline range produces increasing amounts of uncharged amino

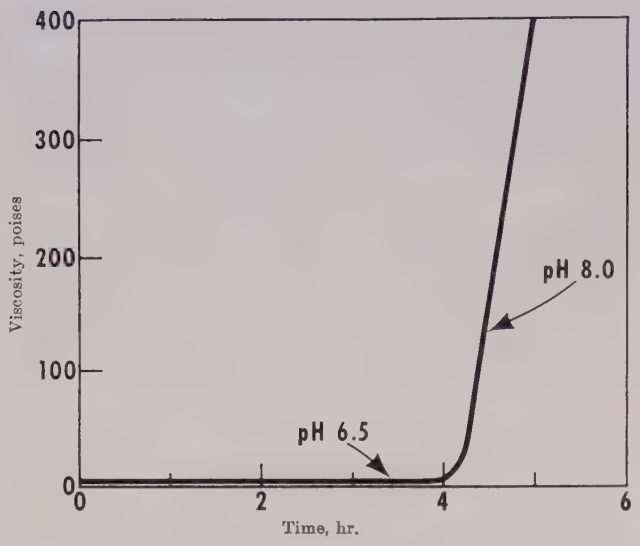

Fig. 3. Rapid gelation of a 1:10 dialdehyde starch-casein dispersion by alkali

groups in proteins (*15*), which are thus made available for reaction with the dialdehyde function of DAS. However the alkalinity that can be used in this reaction is limited by the extent of degradation of DAS which occurs under such conditions of high pH. For this reason it was preferred not to exceed a pH of 8 in this investigation.

Figure 2 shows the regular increase in viscosity of a 7% casein dispersion (1:10 DAS-casein ratio) with increase in pH from 6.8 to 8. This relationship is typical of protein cross-linking reactions in aqueous media. The casein solution was prepared by soaking 7 g. of casein (dry basis) in 93 ml. of water, adding 0.7 g. of borax, and stirring for approximately 30 min. (pH 7.3.). The dialdehyde dispersion was prepared by adding 5 g. of DAS (dry basis) to 45 ml. of water containing 0.5 g. of borax and then stirring and heating at 73°C. for 10 to 20 min. (pH about 6). After rapidly cooling to room temperature, the DAS dispersion was diluted with water to a volume of 50 ml. Seven milliliters of this dispersion was added to the casein solution and agitated to obtain a homogeneous mixture, which was immediately adjusted to the desired pH by adding a small quantity of alkali or acid. Under alkaline conditions the reaction proceeded rapidly with an initial decrease in pH of 0.5 to 0.8 of a unit, and additional alkali was introduced within 15 min. to regain the original pH. When these reactions were allowed to proceed without adjustment to the original pH, reaction rates decreased in proportion to the increased acidity.

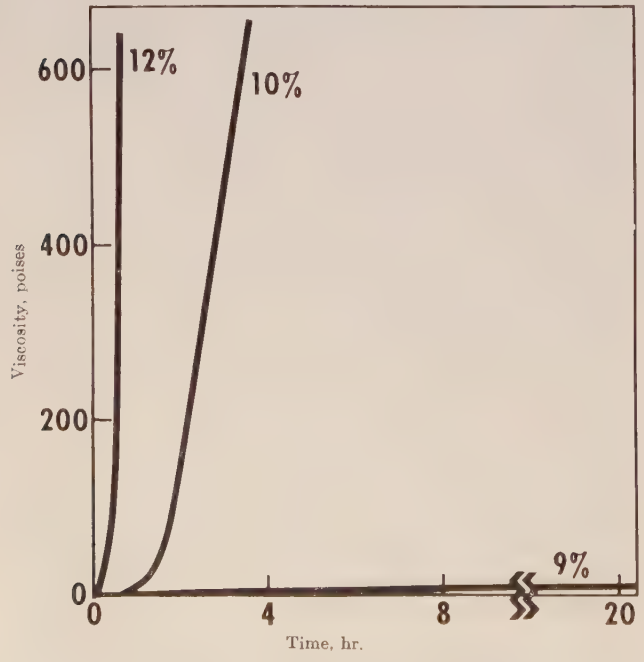

Fig. 4. Concentration-viscosity relationship for a 1:10 dialdehyde starch-casein dispersion

Paper applications of casein require viscosity stability of its solutions over reasonable periods of operating time. Figure 2 illustrates how pH can be used to control the viscosity of a coating mixture of DAS and casein. At pH 6.8 a measurable viscosity difference was obtained only after 4 hr. Higher acidity (pH 6.5) extended this time to over 24 hr. Paper can thus be coated with the unreacted mixture at low pH and the desired viscosity; by application of alkaline reagents, insolubilization of the casein film can be achieved rapidly. Figure 3 shows the effect of this procedure on the viscosity change of a 1:10 DAS-casein mixture.

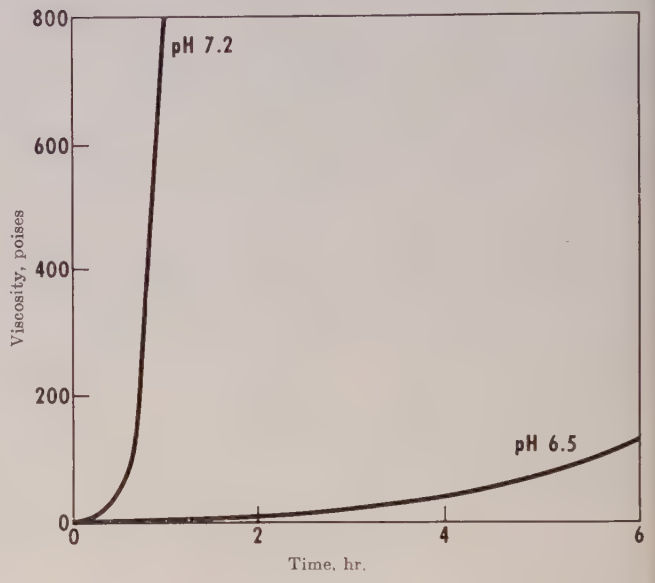

Fig. 5. pH-Viscosity relationship for a 1:20 dialdehyde starch-casein dispersion

Effect of Concentration on Viscosity

Concentration of casein in DAS-casein dispersions under optimal pH conditions for maintaining stable fluidity is also a critical factor in the utilization of such mixtures. Figure 4 shows that practical viscosity is limited to a maximum concentration of casein of about 9% at an initial pH of 6.5 when the DAS-casein ratio is 1:10. Increasing the concentration to 10% produced gelation in 4 hr., and a 12% casein dispersion gelled within 30 min. The final pH of the reaction mixtures was between 5.8 and 6.2. As seen in Fig. 3, a higher pH greatly increases the reaction rate and causes almost immediate gelation of the 1:10 DAS-casein mixture.

A considerable viscosity increase was noted with a 1:20 DAS-casein mixture containing 10% casein at pH 7.2 (Fig. 5). However, viscosity control could be achieved by lowering the reaction pH to 6.5.

SUMMARY

Dialdehyde starch (DAS) has been reacted with casein in aqueous dispersion under various conditions of pH and concentration to produce complexes having irreversible insolubility in water. Maximum combining power of DAS was found to be 25 g. per 100 g. of casein. However, a weight ratio of DAS-to-casein of 1:10 also produced quantitative insolubilization of the protein. Viscosity data are presented for several of the more practical reaction mixtures. The application of these findings to the pigment coating of paper should lead to products having greatly improved water resistance.

LITERATURE CITED

1. Swain, A. P., Kokes, Elsie L., Hipp, N. J., Wood, John L., and Jackson, R.W., *Ind. Eng. Chem.* 40: 465 (1948).
2. Bohmfalk, J. F., Jr., McNamee, R. W., and Barry, R.P., *Ind. Eng. Chem.* 43: 786 (1951).
3. Sutermeister, E. and Browne, F. L., "Casein and Its Fundamental Applications," 2nd ed., page 200, New York, Reinhold Publ. Corp., 1939.
4. Bjorksten, J., "Advances in Protein Chemistry," vol. 6, page 350, New York, Academic Press, Inc., 1951.
5. Pouradier, J. and Venet, Mlle, A. M., "Recent Advances in Gelatin and Glue Research," page 236, New York, Pergamon Press, 1958.
6. Fein, M. L. and Filachione, E. M., *J. Am. Leather Chemists Assoc.* 52: 17 (1957).
7. Seligsberger, L. and Sadlier, C., *J. Am. Leather Chemists Assoc.* 52: 2 (1957).
8. Filachione, E. M., Harris, E. H., Fein, M. L., Korn, A. H., Naghski, J., and Wells, P. A., *J. Am. Leather Chemists Assoc.* 53: 77 (1958).
9. Pfeifer, V. F., Sohns, V. E., Conway, H. F., Lancaster, E. B., Dabic, S., and Griffin, E. L., Jr., *Ind. Eng. Chem.*, 52: 201 (1960).
10. Miles Chemical Co., Elkhart, Ind., Bull. No. 9-200, "Safety Evaluation of Sumstar-S."
11. Beebe, C. W., Happich, M. L., Naghski, J., and Windus, W., *J. Am. Leather Chemists Assoc.* 54: 628 (1959).
12. Kragh, A. M., *Bull. Brit. Gelatine and Glue Res. Assoc.* 9 No. 3: 15 (August, 1958).
13. Whistler, R. L., Chang, P. K., and Richards, G. N., *J. Am. Chem. Soc.* 81: 3133 (1959).
14. Wise, C. S. and Mehltretter, C. L., *Anal. Chem.* 30: 174 (1958).
15. Kenchington, A. W. and Lauder, W. E., "Recent Advances in Gelatin and Glue Research," page 191, New York, Pergamon Press, 1958.

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Demethylation of Lignin and Lignin Models by Aqueous Chlorine Solutions

I. Softwood Lignins

K. V. SARKANEN and R. W. STRAUSS

The characteristics of chlorine-catalyzed hydrolysis of aromatic methoxyl groups were studied using lignin models and various softwood lignins. The rate of the reaction is generally very high except when two *ortho*-substituents other than phenolic-hydroxyl groups are present. This inhibitive influence is also exerted by the *ortho*-chlorine substituents that are competitively introduced into the aromatic nucleus during chlorination. The demethylation characteristics of softwood lignins were amenable to interpretation in terms of the above principles. The hydrolysis of aromatic ether links by the catalytic action of chlorine appears to be a general reaction that makes a significant contribution to the delignification of pulps in bleaching. The reaction is probably related to chlorine-catalyzed hydrolysis of glycosidic bonds in cellulose and various glycosides.

It has been repeatedly observed that wood lignins when treated with chlorine or bromine undergo a substantial loss in methoxyl content (*1–7*). The demethylation reaction is most rapid in an aqueous solution at a low pH, the rate decreasing with increasing alkalinity (*5*). When halogenations of lignin and lignin models are carried out in a nonaqueous medium, even in glacial acetic acid, the demethylation reaction is effectively depressed (*8, 9*) although long reaction periods in anhydrous media have been shown to result in some loss in the methoxyl content (*4, 7*).

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Various opinions have been expressed concerning the nature of the demethylation reaction in aromatic methyl ethers. Hibbert and co-workers (*5*) suggested that chlorine substitution may introduce instability in the aromatic system making the methoxyl group subject to an oxidative degradation by chlorine. Ivancic and Rydholm (*10*), on the other hand, have proposed that the demethylation may be due to an acid-catalyzed hydrolysis of the methoxyl group.

Recent results from this laboratory have proved beyond doubt (*8*) that the demethylation of lignin model compounds by chlorine water is actually a hydrolytic cleavage of the ether bond, catalyzed by molecular chlorine. In view of the fact that such catalytic actions by chlorine are virtually unknown and that aromatic methoxyl groups are, in general, remarkably stable against both acidic and alkaline reagents (*1, 11–13*), the result was somewhat unexpected. However, recent work by Bunton and coworkers (*14*) has demonstrated that the solvolytic cleavage of aromatic methoxyl can occur by the catalytic action of nitronium or nitrosonium ions, species analogous to molecular chlorine as agents for aromatic substitution reactions.

This paper reports on a comprehensive study of the demethylation of aromatic lignin models and various lignin preparations with particular emphasis on the role of the demethylation and related reactions in the bleaching of pulps.

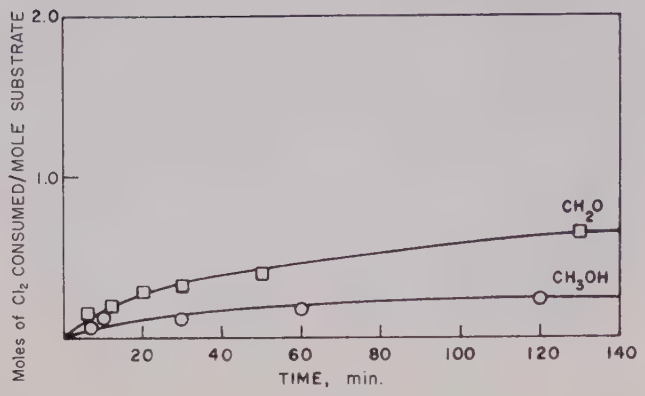

Fig. 1. Consumption of chlorine by methanol and formaldehyde in monochloracetic acid–water medium

Chlorine-to-substrate ratios on a molar basis, 1.84:1 and 2.00:1, respectively.

RESULTS AND DISCUSSION

The most convenient way to study the rate and extent of the demethylation reaction is to determine quantitatively the amount of methanol liberated in the reaction. Methanol reacts with aqueous chlorine solutions very slowly, and in comparison with the fast reaction with the aromatic nucleus, the extent of the former reaction can be ignored (Fig. 1).

The model compounds were, with the exception of anisole and trichloroanisole, derivatives of guaiacol and veratrole. Because most of the compounds studied were water-insoluble, the chlorination experiments were carried out in a mixture of water and monochloroacetic acid. This medium was preferred to aqueous acetic acid because of its greater stability toward molecular chlorine (see under Experimental). The experiments were carried out at room temperature with chlorine additions varying from 1.1 to 1.75 moles per mole of CH_3O.

Figure 2 shows that the liberation of methanol from a number of model compounds is initially a very rapid process. The rapid phase of the demethylation reaction is completed in a few minutes after which the reaction either stops, or is effectively retarded, regardless of substantial amounts of active chlorine still present in the solution.

Three of the compounds studied, namely, anisole, 2,4,6-trichloroanisole and tetrachloroveratrole, showed little tendency of becoming demethylated by the action of chlorine. Anisole was found to be instantaneously converted to 2,4,6-trichioroanisole by the action of chlorine, and the lack of demethylation is probably due to the rapid rate of chlorine substitution. Trichloroanisole and tetrachloroveratrole differ from compounds susceptible to rapid demethylation in that the positions *ortho* to the methoxyl groups are occupied by substituents other than hydrogen. This suggests that the inhibition of demethylation may be due to steric hindrance effects.

Analogous effects by *ortho*-substituents on the demethylation of anisole derivatives by nitric acid in glacial acetic acid medium were observed recently by Bunton and co-workers (*14*). *p*-Chloroanisole was found to yield substantial amounts of 2,6-dinitro-4-chlorophenol, while *0,0'*-disubstituted 2,6-dichloroanisole and 2,6-dimethylanisole were completely resistant toward demethylation by nitric acid.

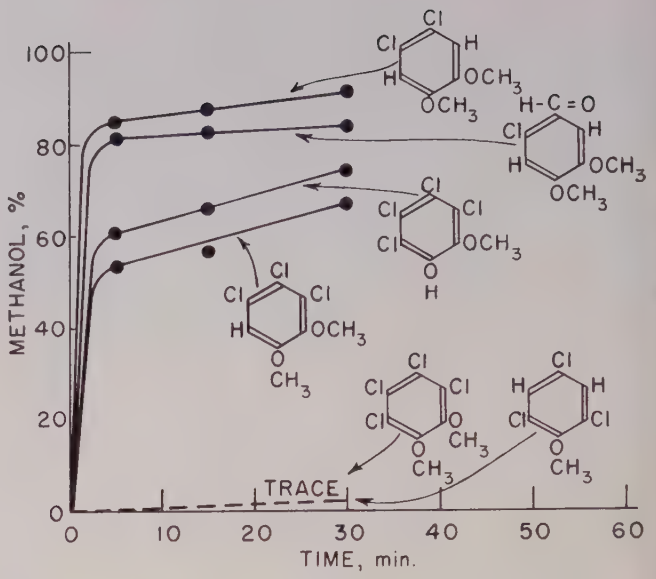

Fig. 2. Formation of methanol in the chlorination of various model compounds in monochloroacetic acid–water medium

Chlorine-to-substrate ratios, on a molar basis: 4,5-dichloroveratrole, 2.46:1; 6-chloroveratraldehyde, 2.44:1; 3,4,5,6-tetrachloroguaiacol, 1.19:1; 3,4,5-trichloroveratrole, 2.38:1; 2,4,6-trichloroanisole, 3.04:1.

In the demethylation by chlorine, the inhibition by *ortho*-substituents appears to be absent when one of these substituents is a phenolic hydroxyl group, such as is present in tetrachloroguaiacol. The demethylation of this compound proceeds without difficulty (Fig. 2). Whether the facilitation of demethylation is due to the relatively small size of the hydroxyl group, or to favorable inductive effects by this group is not possible to decide at the present stage.

Steric hindrance also appears to be the factor which inhibits the demethylation reaction from proceeding to completion in compounds which otherwise demethylate readily. This was demonstrated by isolating tetrachloroveratrole from the products obtained in the chlorination of trichloroveratrole. Consequently, the demethylation reaction is subject to competition by chlorine substitution in the position *ortho* to the methoxyl group which effectively retards further demethylation (see Fig. 3).

Since the generation of methanol from trichloroveratrole levels off at about 60% of the total theoretical amount, the approximate ratio of the rate constant for chlorine substitution to that of demethylation ($k_2:k_1$) is probably about 2:3.

It seems reasonable to assume that similar effects prevent dichloroveratrole and 6-chloroveratraldehyde from becoming completely demethylated. These com-

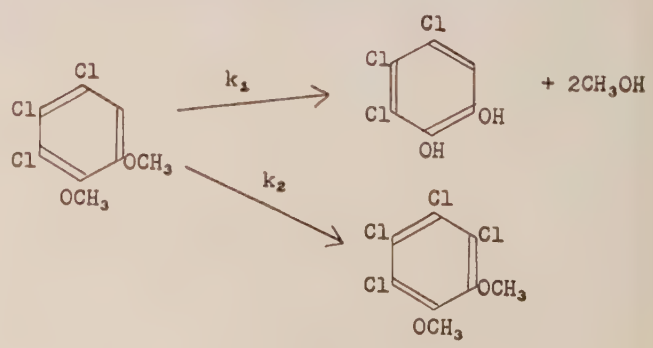

Fig. 3

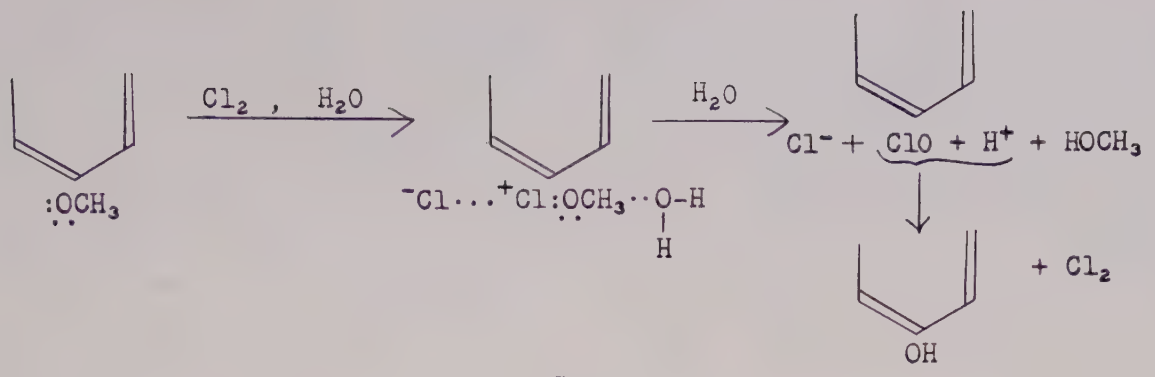

Fig. 4

pounds differ from trichloroveratrole in that two instead of one chlorine substitution steps are necessary to reach the sterically inhibited situation, and consequently, the demethylation reaction should be in a more favorable position to compete with the formation of tetrasubstituted veratrole derivatives. Substantially higher levels of demethylation are, indeed, found in the chlorination of these compounds (Fig. 2).

The Mechanism of the Demethylation Reaction. In an earlier publication (*8*), two mechanisms of the demethylation reaction were considered, consisting of the attack of the polarized chlorine molecule at the position *para* to the methoxyl group, or, alternatively, at the ether oxygen of the methoxyl group (see Fig. 4). The former mechanism now seems less probable. No major effect on the demethylation rate was observed, whether the group *para* to a methoxyl was chlorine or an aldehyde group (cf. Fig. 2). On the other hand, the strong inhibitive effects of *ortho*-substituents are also not easily compatible with the former mechanism and, consequently, appear to be due either to the inhibition of the formation of the transition complex of the latter mechanism or to the inhibition of the proper solvation of this complex.

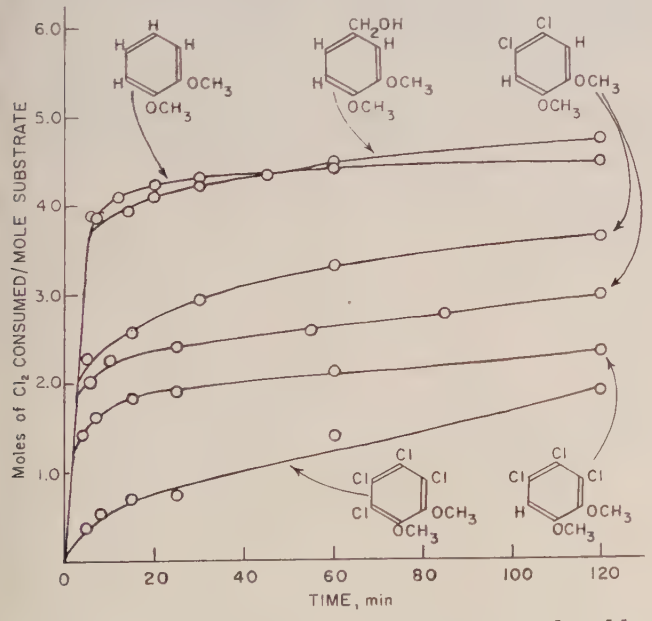

Fig. 5. Consumption of active chlorine in the chlorination of various models in monochloroacetic acid–water medium

Initial chlorine-to-substrate ratios, on a molar basis: veratrole, 6.83:1; veratryl alcohol, 6.70:1; 4,6-dichloroveratrole, 7.96:1 and 5.52:1; 3,4,5-trichloroveratrole, 7.75:1; 3,4,5,6-tetrachloroveratrole, 7.48:1.

The lowered acidity of phenols containing bulky *ortho*-substituents (*15*), which has been assigned to decreased solvation of the phenolate ion because of steric effects, offers here a close analogy.

It seems likely that the hydrolysis of aromatic ether groups by chlorine in aqueous media is a general reaction which is not limited to methoxyl groups, but occurs in higher ethers as well. Preliminary chlorination studies on catechol diethyl ether indicate that the ether hydrolysis occurs with equal ease as in the case of veratrole derivatives.

Related reactions have also been observed in the carbohydrate series. Hydrolysis of glycosidic bonds by the action chlorine and other oxidizing agents have been repeatedly observed under conditions eliminating the possibility of acidic hydrolysis. For instance, Theander (*16*) and Henderson (*17*) have demonstrated the formation of glucose in the chlorination of methyl-β-glucopyranoside at pH 7. Substantial amounts of methanol are formed simultaneously (*18*). The formation of glucose in the chlorination of cellulose has been likewise reported (*17*). Zienius and Purves have demonstrated the formation of galacturonic acid from pectic acid and methyl-α-D-galacturonoside by the action of hydpochlorite, chlorine dioxide, and chlorites (*19*). While the nature of the degradation reaction has not

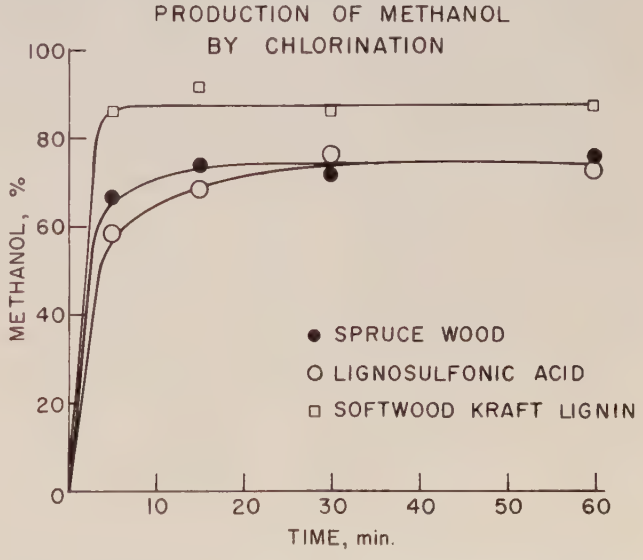

Fig. 6. Formation of methanol in the chlorination of extracted Norway spruce wood meal, softwood lignosulfonic acid and softwood kraft lignin in monochloroacetic acid–water medium

Chlorine-to-methoxyl ratios, on a molar basis: spruce wood meal, 3.35:1; lignosulfonic acid, 3.12:1; softwood kraft lignin 3.27:1.

Table I. Amount of Chlorine Consumed in a Fast Reaction in the Chlorination of Various Model Compounds in Monochloroacetic Acid–Water Medium

Compound	*Moles of active chlorine/-mole of substrate*	
	Initially added	*Rapidly consumed*
Veratrole	6.83	4
Veratryl alcohol	6.70	4
4,5-Dichloroveratrole	5.52	2
4,5-Dichloroveratrole	7.96	2
3,4,5-Trichloroveratrole	7.75	1
3,4,5,6-Tetrachloroveratrole	7.48	0

been rigorously established in each individual case, a hydrolytic mechanism by the catalytic action of the oxidant appears probable.

The Rate of Chlorine Consumption by Model Compounds. Figure 5 presents the chlorine consumption as a function of time for various model compounds. The determinations were carried out under the same conditions as the demethylation experiments.

It should be pointed out that the interpretation of the chlorine consumption curves is not clear-cut. Each compound reacts in a rather complex way, several competing and consecutive reactions being involved. Furthermore, the quinones formed are capable of oxidizing potassium iodide to free iodine, causing an error in the active chlorine determination.

It is nevertheless interesting to note that, in general, a rapid and a slow reaction phase are clearly discernible. The chlorine consumption during the rapid phase of chlorination is recorded in Table I and corresponds, in each case, to the amount of chlorine required to convert the compound into tetrachloroveratrole or tetrachlorocatechol, or to both. Although no definite conclusions can be based on this observation, the suggestion is imminent that the extent of oxidation to quinones may remain relatively insignificant until the chlorine substitution and electrophilic displacement reactions are fully completed.

Demethylation of Softwood Lignins. The merits of any work with model compounds is dependent upon how well the knowledge gained from their reactions can be correlated with the behavior of the more complex lignin molecule. Figure 6 shows the production of methanol by chlorination of spruce wood meal, lignosulfonic acid, and softwood kraft lignin. The general pattern corresponds to that of the model compounds, consisting of a rapid liberation of methanol followed by a leveling-off phase. Of special importance is the rapid cleavage of methoxyl in the sprucewood meal. While the lignosulfonic acid and softwood kraft lignin were both in solution, the two-phase system in the chlorination of wood meal might be expected to result in a slower reaction owing to limited accessibility. The observed high rate of demethylation indicates that the accessibility is not a major factor in the chlorination of wood meal in the medium used.

Kraft lignins are considered to be highly condensed in addition to having most of the phenol groups in the 4-position unetherified (*20*). As shown in the model-compound studies, the presence of a free phenolic hydroxyl group facilitates demethylation and relieves the steric inhibition effect. The softwood kraft lignin was, indeed, found to demethylate to a greater extent than either sprucewood or lignosulfonic acid. It is difficult to explain, however, why exhaustive methylation of the kraft lignin with diazomethane failed to lower the relative extent of demethylation to any substantial degree.

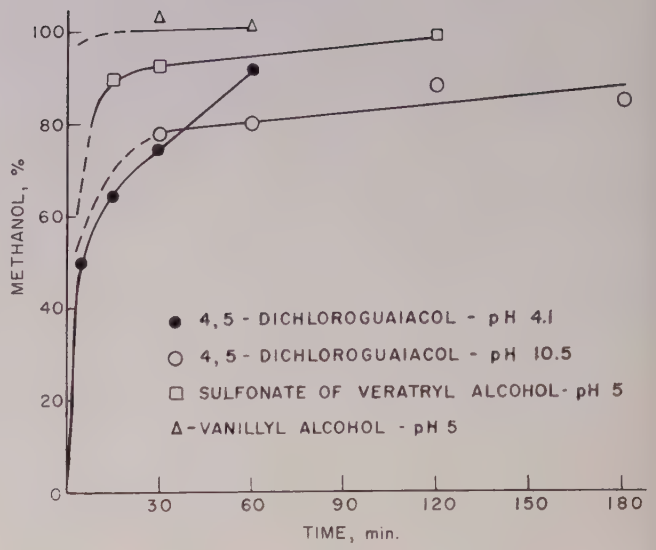
METHANOL, %
TIME, min.
4,5 - DICHLOROGUAIACOL - pH 4.1
4,5 - DICHLOROGUAIACOL - pH 10.5
SULFONATE OF VERATRYL ALCOHOL - pH 5
Δ - VANILLYL ALCOHOL - pH 5

Fig. 7. Formation of methanol by chlorinating model compounds in an aqueous solution in a pH range 4 to 10

Chlorine-to-substrate ratios, on a molar basis: 4,5-dichloroguaiacol. 3.24:1 at pH 4.1 and 5.00:1 at pH 10.5; 3,4-dimethoxybenzyl-ω-sulfonic acid (sulfonate of veratryl alcohol), 3.45:1; vanillyl alcohol, 3.56:1.

During the course of this investigation, Sato and coworkes (*26*) published data on the amounts of methanol liberated in the chlorination of spruce and beech lignosulfonic acids, thiolignin and hydrochloric acid lignin. Their results are in general agreement with levels of demethylation observed in the present study.

Effect of pH on Demethylation. The demethylation studies described in the earlier sections were all performed in a mixture of water and monochloroacetic acid. In order to investigate the effect of pH on the demethylation, a number of water-soluble model compounds and lignosulfonic acid were subjected to chlorination in buffered aqueous solutions.

Earlier studies have demonstrated that treatment of dichloroveratrole with hypochlorite solution results neither in color formation nor can a measurable ioniza-

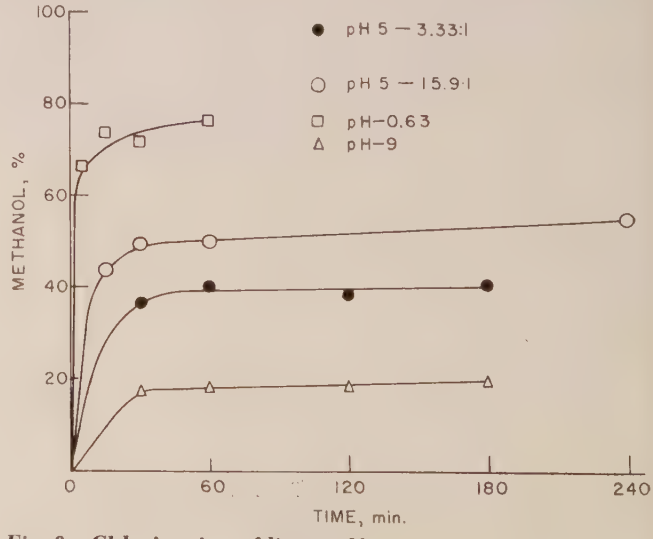

Fig. 8. Chlorination of lignosulfonic acid in aqueous solution (pH-range 5 to 9)

Chlorine-to-methoxyl ratios, on a molar basis: 3.12:1 at pH 0.8; 3.33:1 and 15.9:1 at pH 5; 3.26:1 at pH 9.

tion difference spectrum be observed (*8*). When vanillyl alcohol, 4,5-dichloroguaiacol and 3,4-dimethoxytoluene-ω-sulfonic were treated with chlorine solutions at pH above 4, the solutions remained likewise colorless. It was somewhat unexpected, therefore, that quantitative determinations revealed a substantial generation of methanol, which in the pH region 4 to 5 was practically complete for the models studied (Fig. 7).

It seems probable that the oxidative degradation of the catechol and quinone intermediates is very rapid in comparison with the chlorination in an acid pH range.

The behavior of lignosulfonic acid was found to be different from that of the models. At pH 5, the final extent of demethylation was lowered below 50% of the theoretically possible value (Fig. 8). The methanol liberation appears also to be dependent on the chlorine dosage, regardless of the fact that active chlorine was still present at the end of each reaction series. At pH 9, the demethylation level is further reduced, even below the level of free phenolic units in the lignosulfonic acid. In general, the demethylation reaction at higher pH levels is complex and requires more extensive studies with a larger variety of models and lignin preparations for proper evaluation.

The Significance of the Demethylation and Related Reactions for the Chlorination and Bleaching of Softwood Lignins. As pointed out earlier in this paper, it seems reasonable to assume that the dealkylation reactions occurring in the chlorination of wood and residual lignin in pulps are not limited to demethylation, but that chlorine-catalyzed hydrolysis of aromatic ether links takes place as well. The latter process should be especially facilitated after the methoxyl on the same unit has been removed, because of the demonstrated activating influence of an *ortho*-hydroxyl group. On the other hand, if the demethylation is inhibited for steric reasons, the same inhibiting effect should extend to the ether link at the 4-position of the same unit. For these reasons, each guaiacyl propane unit in softwood lignin or lignosulfonic acid has a chance to react in two different ways, as shown in Fig. 9.

If the proposed picture is correct, the amount of methoxyl resistant toward hydrolysis by chlorine should equal the amount of unhydrolyzed 4-ether linkages, on a molar basis. Since approximately 25% of methoxyl remain in softwood lignosulfonic acid after chlorination, the same fraction of guaiacylpropane units are likely to remain in the etherified condition. Although the demethylation pattern of sprucewood meal is similar to that of lignosulfonic acid, an estimation of this sort is not justified until the fate of methoxyl groups attached to the carbohydrates is clarified.

In order to roughly estimate the extent of 4-ether cleavage, it should be first observed that about 33% of guaiacylpropane units in wood lignin (*21*) and slightly more in the lignosulfonic acid are unetherified and contain a free phenolic hydroxyl group. These units are likely to become completely demethylated because of the activating influence of the free phenolic hydroxyl group. Consequently, approximately 42% of such monomeric units are left that undergo both demethylation and ether cleavage at the 4-position.

The hydrolysis of the 4-ether bond can only result in the cleavage of the lignin molecule in uncondensed units (X, R, = H). It is not possible to estimate the share of condensed units that undergo this reaction, but it seems likely that they would not exceed 50%. Consequently, the order of magnitude of cleavage of the lignin molecule by dealkylation reaction still appears extensive, amounting to perhaps 20% of the monomeric units.

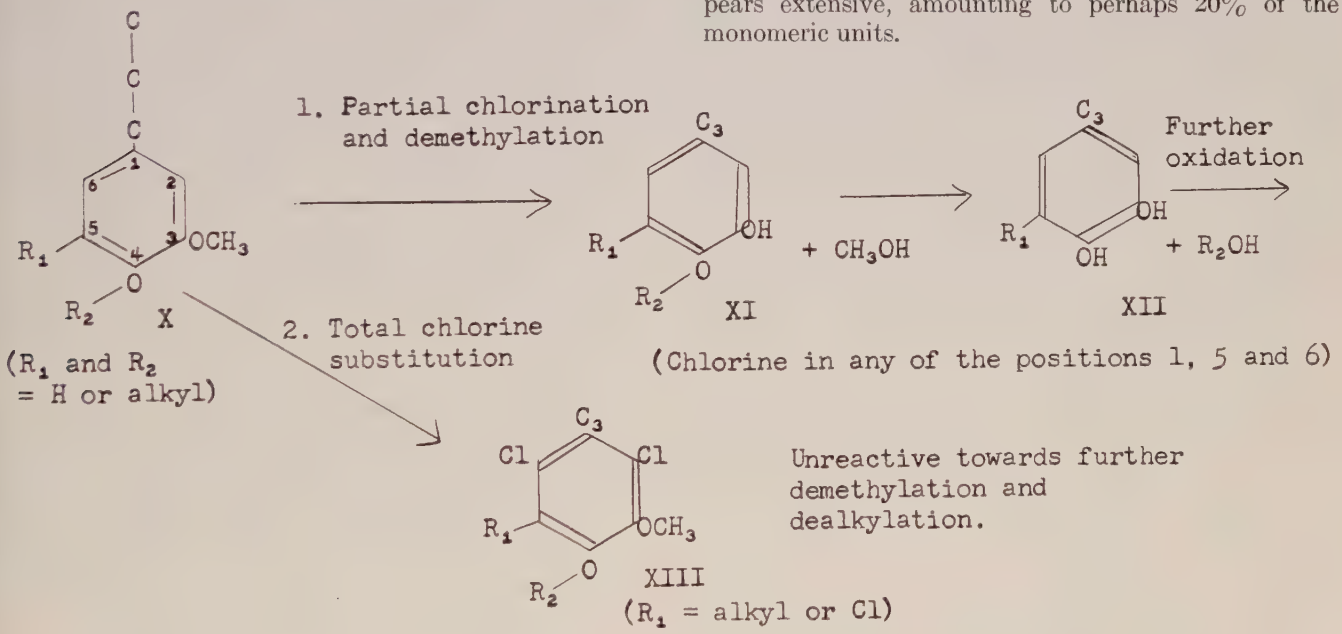

Fig. 9

Secondary condensation reactions that may occur in the sulfite pulping process are likely to decrease the effectiveness of the 4-ether hydrolysis in cleaving the lignin molecule. Condensed residual lignins in sulfite pulps are indeed known to resist effectively the chlorination treatment. As far as kraft lignins are concerned, the 4-ether linkages have been effectively hydrolyzed already in the alkaline pulping process and the secondary condensation is extensive. The lack of contribution to lignin degradation by the ether cleavage reaction is probably one of the factors contributing to the ineffectiveness of acidic chlorination in the bleaching of kraft pulps.

EXPERIMENTAL

Materials

The preparation of most of the model compounds have been described earlier (*8*, *22*). 4,5-Dichloroguaiacol was synthesized according to Matell (*23*) and the barium salt of 3,4-dimethoxytoluene-ω-sulfonic acid following the procedure by Lindgren (*24*). Alcohol-benzene extracted spruce wood meal was prepared according to the standard procedures (MeO = 4.62%). An isolated softwood lignosulfonic acid preparation with a methoxyl content 10.52% was kindly supplied by Dr. Philip Luner, of the Empire State Paper Research Institute. Indulin AT, a commercial kraft lignin preparation from southern pine (MeO = 14.8%, West Virginia Pulp and Paper Co., Luke, Md.) was used to study the properties of softwood kraft lignins in chlorination. After five successive methylations with diazomethane in ether the methoxyl content increased to 22.6%.

Chlorination Expreriments

Since most of the model compounds were insoluble in water, a solvent that was both miscible with water and would not consume chlorine was necessary. Mixtures of water with acetic acid, ethanol, dioxane, and ethylene glycol were all found to consume chlorine at a measurable rate. However, solutions of chlorine in a mixture of monochloroacetic acid and water were found to be stable and sufficiently good solvents to dissolve the various model compounds. Monochloroacetic acid, 2000 g., was dissolved in 750 g. of water to give a final volume of 2100 cc. Based on the dissociation constant of monochloroacetic acid (1.4×10^{-3}) the pH of the solution was estimated to be approximately 0.9. This mixture was used consistently in all chlorinations in an acidic medium. The evaporation of chlorine from this solution was substantially depressed in comparison with chlorine water. This property is particularly advantageous for kinetic studies.

The determinations of the rate of methanol formation were performed in the following fashion. The compound (sufficient to contain 0.02–0.05 g. OCH_3) was dissolved in the monochloroacetic acid solvent and placed in a stoppered flask in a constant temperature bath adjusted to 20°C. A separate sample was used for each determination. Sufficient chlorine dissolved in the same solvent was added. At the end of the reaction time, sufficient amount of $NaHSO_3$ solution was added to destroy the excess chlorine. The pH of the solution was then raised to 10 to 10.5 by addition of 50% NaOH with precautions to keep the solution cold. The final volume was 200 to 250 ml.

The mixture was distilled and about 90 ml. of distillate collected. To prevent loss of methanol, the receiver was immersed in a water-ice bath and the delivery tube extended into a small amount of water in the receiver. No formaldehyde was discovered in the distillates from the model-compound chlorinations. However, small amounts of it were present in the various lignin and wood meal distillates. Since formaldehyde interferes with the methanol determination, the following procedure was developed for its removal.

Saturated solution of dimedone (5,5-dimethylcyclohexane-1,3-dione) in water (25 ml.) was added to the distillate and the pH adjusted to 4.8. After standing at room temperature overnight, the formaldehyde-dimedone precipitate, whenever formed, was filtered off. The solution was then made alkaline with NaOH and distilled, collecting 90 ml.

The quantitative methanol determinations were carried using aliquots of the final distillate. The procedure used was essentially the modification by Adler and Hernestam (*25*) of the standard method of oxidizing methanol to formaldehyde with $KMnO_4$ and determining the latter colorimetrically by the chromotropic acid method. Beckman Model DU spectrophotometer was utilized for the colorimetric determinations employing a standard curve obtained from measurements with known amounts of methanol.

The chlorine-consumption curves were likewise determined in monochloroacetic acid solution at 20°C. The chlorine concentrations were measured by withdrawing a sample by displacement of the liquid with nitrogen into a pipet and titrating the active chlorine by the standard iodometric procedure.

Aqueous solutions and water-soluble model compounds and lignin preparations were used for demethylation studies at higher pH values. The solutions were adjusted to pH levels 5 and 9 with standard acetate and borate buffers, respectively.

LITERATURE CITED

1. Freudenberg, K., Beltz, W., and Niemann, C., *Chem. Ber.* 62B, 1554 (1929).
2. Friedrich, A. and Pelikan, E., *Biochem. Z.*, 239, 461 (1931).
3. Harris, E. E., Scherrard, E. C., and Mitchell, R. L., *J. Am. Chem. Soc.* 56, 889 (1934).
4. Brauns, F. E., *Paper Trade J.* 103, 36 (1936).
5. White, E. V., Swartz, J. N., Peniston, Q. P., Schwartz, H., McCarthy, J. L., and Hibbert, H., *Tech. Assoc. Papers* 24, No 1, 179 (1941).
6. Newcombe, A. G. and Marshall, H. B., *Can. J. Tech.* 33, 152 (1955).
7. Polcin, J., *Sbornik vyzkum. praci z oburu celulozy a papiru* 1, 217 (1956); *C.A.* 51, 13388 (1957).
8. Sarkanen, K. V. and Dence, C. W., *J. Org. Chem.* 25, 715 (1960).
9. Fort, R., Sleziona, J., and Deniville, L., *Bull. soc. chim. France* 810 (1955).
10. Ivancic, A. and Rydholm, S. A., *Svensk Papperstidn.* 62, 16, 554 (1959).
11. Burwell, R. L., *Chem. Rev.* 54, 615 (1954).
12. Prey, V., *Chem. Ber.* 75B, 445 (1942).
13. Wacek, A. V., Limontschew, W., and Aas, C., *Ind. Eng. Chem.* 49, 1389 (1957).
14. Bunton, C. A., Hughes, E. D., Ingold, C. K., Jacobs, D. I. H., Jones, M. H., Minkoff, E. J., and Reed, R. I., *J. Chem. Soc.* 2628 (1950).
15. Coggeshall, N. D. and Glessner, A. S., Jr., *J. Am. Chem. Soc.* 71, 3150 (1949).
16. Theander, O., *Svensk Papperstidn.* 18, 581 (1958).
17. Henderson, J. T., *J. Am. Chem. Soc.* 79, 5304 (1957).
18. Sarkanen, K. V., Dence, C. W., and Grewal, G. S., unpublished results.
19. Zienius, R. H. and Purves, C. B., *Can. J. Chem.* 37, 1820 (1959); *Tappi* 43, 27 (1960).
20. Enkvist, T., Alm, B., and Holm, B., *Paperi ja Puu* 38, 1 (1956); K. Sarkanen and C. Schuerch, *Anal. Chem.* 27, 1245 (1955).
21. Hernestam, S. and Adler, E., *Svensk Kemisk Tidskrift* 67, 37 (1955).
22. Dence, C. and Sarkanen, K., *Tappi* 43, 87 (1960).
23. Matell, M., *Acta Chem. Scand.* 9, 1017 (1955).
24. Lindgren, B. O., *Acta Chem. Scand.* 3, 1011 (1949).
25. Adler, E. and Hernestam, S., *Acta Chem. Scand.* 9, 319 (1955).
26. Sato, K., Mikawa, H., and Ebisawa, K., *J. Chem. Soc. Japan, Ind. Eng. Section 61*, 1090 (1958).

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Studies on the Mechanism of Chlorine Dioxide Bleaching

R. A. MURPHY, K. KAKEHI, and K. V. SARKANEN

The partial conversion of certain lignin model compounds to peroxides by the action of aqueous chlorinedioxide has been established. The possible mechanism of such reactions as well as the significance of peroxidic intermediates in the bleaching and delignification processes of wood and pulp lignins are discussed.

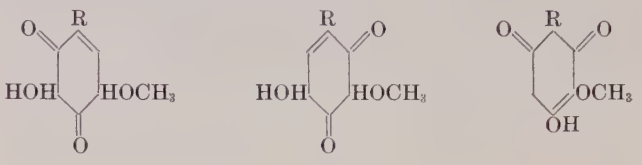
THE ability of chlorine dioxide to degrade lignin to colorless, low-molecular weight products without affecting the carbohydrate constituents makes it a bleaching agent of unparalleled efficiency. The effective delignifying action of chlorine dioxide has been known for a long time. Use of this reaction is made not only in pulp bleaching, but also in the preparation and analytical determination of holocellulose in woody materials. The oxidative mechanism which causes the transformation of the lignin to soluble products is, however, almost completely unknown.

Schmidt and co-workers (*1*) have shown that aqueous chlorine dioxide is practically unreactive towards most saturated aliphatic compounds such as alcohols, amines, carboxylic acids, nitriles, and amides. Unsaturated compounds generally react with relative ease, except when they contain electron-withdrawing groups, such as carboxylic acid groups, attached to the unsaturated system. Aromatic hydrocarbons, such as benzene and naphthalene are quite unreactive, whereas phenol derivatives such as resorcinol, nitrophenols, and phenol carboxylic acids react with ease. These empirical data appear to suggest that the reactivity of an aromatic or unsaturated system towards chlorine dioxide is somehow determined by the electron density in that system, electron-withdrawing substituents decreasing, and electron releasing groups promoting the reactivity.

Since the guaiacyl and syringyl nuclei in lignin are highly activated by several electron-releasing groups, it seems probable that these aromatic groups may represent the primary sites of attack by chlorine dioxide.

OXIDATION OF VANILLIN WITH CHLORINE DIOXIDE

To study the nature of the oxidative reaction between chlorine dioxide and aromatic lignin model compounds, it appeared desirable to re-investigate the nature of the crystalline product isolated some years ago, in 25% yield, from the chlorine dioxide oxidation products of vanillin by Husband, Logan, and Purves (*2*). These authors found that the empirical composition of the crystalline product $C_7H_5O_4(OCH_3)$ corresponded to a dihydroxyvanillin. However, this compound, as well as a crystalline acid $C_7H_5O_5(OCH_3)$ that was obtained by oxidizing vanillin with an acidic chlorite solution, both proved to be nonaromatic compounds. On the basis of extensive studies on these compounds and their derivatives, Purves and co-workers brought into consideration as possible structures for the aldehyde and the acid the following three structures which are *meta*-diketones derived from 5,6-, 2,5-, and 2,6-dihydroxyvanillin, respectively:



R = CHO or CO_2W

Fig. 1

Although the structures in Fig. 1 are in accordance with most of the experimental data presented by Purves and co-workers, there exist certain discrepancies. First, there is no obvious reason why the *meta*-diketones should be more stable than their aromatic tautomers. Secondly, the ring carbonyls in neither of the new compounds (or their derivatives) could be converted to dinitrophenylhydrazones. Finally, enolization of the ring carbonyls in active hydrogen determination is to be expected, but was not observed experimentally. A re-investigation of the new compounds revealed that they represent peroxidic rather than diketone structures.

It has been demonstrated earlier that both dialkylperoxides and transannular peroxides react with hydroiodic acid in glacial acetic to liberate one mole of iodine. The quantitative determination of these compounds is based on this reaction (*3*). Unlike hydroperoxides and diacylperoxides, they are not reduced by potassium iodide in isopropanol-acetic acid solution.

When the aldehyde $C_7H_5O_4(OCH_3)$ (II) and the acid $C_7H_5O_5(OCH_3)$ (III) were subjected to the above tests, they liberated one mole of iodine in the dialkylperoxide determination while the test for hydroperoxides was negative. The completely methylated acid (IV) and the demethylated acid (V), both prepared according to the directions of Purves and co-workers (2), were found to behave in a like manner. When hydrogenated with palladium black catalyst in dioxane solution, each of the compounds II, III, and IV absorbed one mole of hydrogen and was converted to a peroxide-free product.

By these results, the existence of a peroxide bridge is almost certain. The assignment of the position between the 2- and 5- carbon atoms for the peroxidic group is supported by a number of experimental data, although not proved rigorously as yet. This evidence is summarized briefly in the following.

R. A. MURPHY, participant of the NSF undergraduate program, K. KAKEHI, Graduate Student, and K. V. SARKANEN, Associate Professor, Cellulose Research Institute, State University College of Forestry at Syracuse University, Syracuse, N. Y.
This project was sponsored by the Wood Chemistry Committee and was supported by Tappi Grant No. 176.

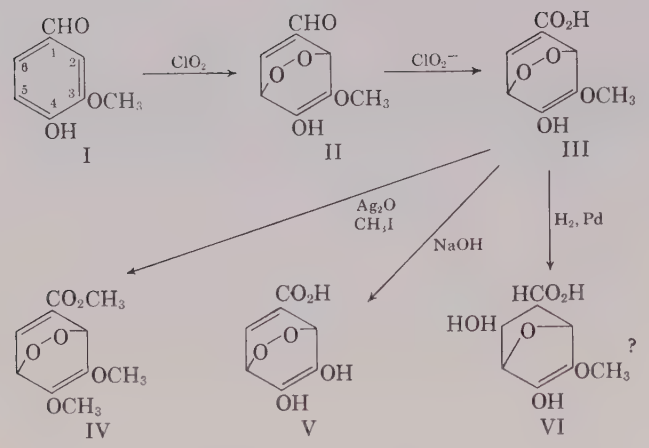


Fig. 2

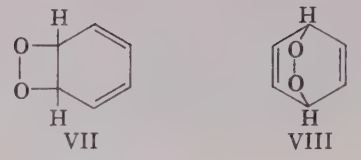


Fig. 3

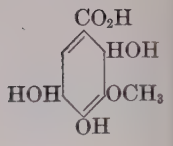


Fig. 4

The conversion of vanillin to peroxidic compounds takes place with a simultaneous change of the aromatic system to a hydroaromatic one as evidenced both by infrared and ultraviolet spectra of the products. In principle, this change can be caused either by the addition of a peroxide group across a double bond or across a 1,3-diene system, resulting in the formation of a 1,2- or 1,4-(transannular) peroxide, respectively (Fig. 3)

Of these, the 1,2-peroxide arrangement is likely to be thermally unstable and should easily rearrange to an isomeric dialdehyde. Furthermore, the 1,2-diene system present can be expected to undergo Diels-Alder type addition reactions. Catalytic hydrogenation of the peroxy group should yield a *cis*-1,2-glycol which, in turn, could be detected by various means.

However, the peroxidic compounds were found to be highly stable towards thermal degradation. For instance, the ester IV is capable of standing temperatures up to 200°C. without decomposition. The peroxyacid III does not add maleic anhydride and its crystalline reduction product VI does not form an isopropylidene derivative and is unreactive towards periodate.

Consequently, the 1,2-peroxidic arrangement is highly unlikely and the transannular peroxide is left as the most probable alternative. The enolic hydroxyl in position 4 in the peroxyacid III is acidic enough to be titrated potentiometrically. This suggests its existence as a part of an ene-diol monomethyl ether system and consequently, a double bond should exist between the 3- and 4-carbon atoms. The assigned structure for peroxyacid III gains further support from the fact that both ultraviolet and infrared spectra characterize it as an α,β-unsaturated acid.

The difficulties in determining the structure of the peroxy compound by chemical means is due to secondary reactions that occur in the reduction of the peroxide group. When the reduction is carried out with hydroiodic acid, the product is recovered in the form of polymeric resin. Catalytic reduction converts the peroxyacid III to a crystalline compound whose analytical composition is identical with the expected product (Fig. 4)

However, the acid does not consume periodate and the infrared spectrum is devoid of the 1600 $cm.^{-1}$ absorption peak of the original peroxyacid indicating the absence of α,β-unsaturation. Conductometric titration shows the presence of two acidic groups. The structure III in Fig. 2 has been assigned to the reduced acid, tentatively.

Hydrogenation experiments on the peroxyacid and the peroxyaldehyde by Purves and co-workers (*2*), using reduced palladium oxide catalyst, are not in accordance with the results obtained in this investigation. The cause of the discrepancy is still unclear.

PEROXIDIC INTERMEDIATES IN DELIGNIFICATION BY CHLORINE DIOXIDE

The formation of hydroaromatic peroxides from aromatic compounds by the action of chlorine dioxide is not limited to vanillin. It was found that other aromatic methyl ethers, such as guaiacol and veratrole, also give determinable amounts of peroxides in chlorine dioxide treatment. No peroxides were detected from chlorine dioxide-oxidized anisole.

The fact that the peroxide determination is nonspecific, to a certain degree, limits its utility as a tool to quantitatively determine the peroxidic intermediates in chlorine dioxide oxidations. While many aromatic compounds such as vanillin, guaiacols, and veratrole, do not liberate iodine in the peroxide determination, certain nonperoxidic aliphatic compounds are known to be reactive with hydroiodic acid under relatively mild conditions. As an example, glycerol is converted to isopropyliodide liberating one mole of iodine when heated with hydroiodic acid in the temperature range 60 to 100°C. Similarly, extracted spruce wood meal was found to contain nonperoxidic constituents that liberate iodine in the peroxide determination (*4*).

The hydroaromatic peroxides possess, however, other properties potentially suited for their detection and quantitative determination. As illustrated by Table I, the transformation of aromatics to hydroaromatic peroxides is accompanied by a substantial hypsochromic shift in light absorption. Consequently, spectrophotometric methods may provide a tool to study the chlorine dioxide oxidation of soluble lignin preparations such as lignosulfonic acid.

Indeed, studies carried out by Smith and Purves (*5*) on chlorine dioxide-oxidized lignosulfonic acid indicate that the aromatic nuclei had been modified in the oxidation process. Their preparation, although of high molecular weight, was found to be devoid of the light absorption maximum at 280 μ, characteristic of lignin derivatives. Lack of further experimental

Table I. High Wavelength Absorption Maxima of Peroxy Compounds

Compound	*Solvent*	λmax.	ε
Peroxyaldehyde (II)	EtOH	265	16,600
Peroxyaldehyde (II)	0.1 *N* aq. NaOH	320	12,900
Peroxyacid (III)	EtOH	*ca.* 240 (shoulder)	9,300
Hydrogenated peroxyacid (VI)	EtOH	221	11,100

evidence at this point prevents definite conclusions as to whether the abnormal light absorption was due to the formation of hydromatic peroxides, but such assumption seems at least highly probable.

LITERATURE CITED

1. E. Schmidt and K. Braunsdorf, *Chem. Ber.* 55, 1529 (1922).
2. R. M. Husband, C. D. Logan, and C. B. Purves, *Can. J. Chem.* 33, 81 (1955).
3. F. H. Dickey, J. L. Raley, F. F. Rust, R. S. Tresede, and W. E. Vaughan, *Ind. Eng. Chem.* 41, 1673 (1949).
4. M. Gupta, C. Dence, and K. V. Sarkanen, unpublished results.
5. D. M. Smith and C. B. Purves, *Ind. Eng. Chem.* 49, 1394 (1957).

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Paper Reinforcement with Liquid Urethane Emulsions

R. L. BERGER and C. H. GELBERT

Aqueous emulsions can be prepared from isocyanate-terminated liquid urethane polymers. This paper describes their preparation and discusses the factors affecting their physical and chemical stability. Physical properties of paper saturated with these emulsions are described. The isocyanate groups of the urethane polymer react sufficiently slowly with water that their emulsions can be used for several hours after preparation to give a high degree of reinforcement to paper. Curing of the dried saturated paper is accomplished by the reaction of moisture in the air with the isocyanate groups of the polymer. Papers treated with urethane polymers possess outstanding internal bond strength and wet tensile strength. Wet-strength development is considered to be due to a reaction between the isocyanate group of the polymer and hydroxyl groups of the cellulose, and is not a result of sizing or reduced water absorption. Dry tensile strength and water absorption are comparable to the values obtained through saturation with conventional polare lastomers. Urethane-treated papers show good heat-aging properties at temperatures up to 125°C.

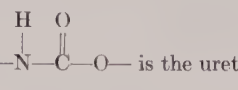
MANY plastic and elastomeric materials are used as binders for cellulosic fibers. Were it not for these additives, paper products would be unsuitable for many of their present uses. The additives vary considerably in their ability to improve paper properties, and no single material is suitable for all uses. For this reason, new polymeric materials are constantly being developed and evaluated as paper additives.

One of the newer classes of elastomers, the polyurethanes, is finding increasing use in the rubber industry in applications requiring outstanding elastomeric properties such as high tensile and tear strengths, high load-bearing capacity, and excellent abrasion, ozone, and solvent resistance. This paper deals with the preparation of polyurethane elastomer emulsions, their use as paper saturants, and the properties obtained from paper treated with them.

Polyurethane elastomers are prepared by making diisocyanates react with compounds containing active hydrogen atoms, usually hydroxyl-terminated polyesters or polyethers. The chemical reaction which occurs between isocyanate and hydroxyl groups leads to the formation of polyurethanes from which the name "urethane elastomers" is derived [equation (1)]:

$$OCN{-}R{-}NCO + HO{-}R{-}OH \rightarrow OCN{-}R{-}\underset{\displaystyle H}{\overset{}{N}}{-}\overset{\displaystyle O}{\overset{\|}{C}}{-}O{-}ROH \quad (1)$$

R. L. BERGER and C. H. GELBERT, Elastomers Laboratory, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., Contribution No. 165.



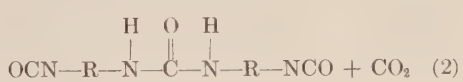
$$-N(H)-C(=O)-O- \text{ is the urethane group.}$$

Urethane polymers can be prepared as millable solids and as viscous liquids suitable for casting. This study concerns the latter group, the liquid casting resins. An excess of diisocyanate is made to react with a high-molecular-weight glycol to give a fluid resin containing reactive isocyanate end groups. This product is then cured with compounds containing active hydrogen atoms to give useful products.

It was considered possible that the addition of such elastomers to paper might result in chemical reaction of the isocyanate end-groups with the hydroxyl groups in the cellulose. If this occurred, improved tensile strength and internal fiber bonding might be achieved with a relatively small amount of urethane.

There are three methods of using liquid urethane casting polymers to treat paper: (1) coating with undiluted resins, (2) saturating or coating with a solution of polymer in a nonreactive solvent, and (3) saturating from emulsions. The high viscosity of the resins even at elevated temperatures makes the first method impractical. The second method involves the handling of large amounts of solvents which may be toxic or flammable. For general applicability, emulsion systems would offer greater ease of handling, simplicity of processing equipment, and flexibility and safety.

In view of these advantages, the preparation of urethane emulsions and their evaluation as paper saturants was undertaken. Some prior work bearing on this problem had been reported (*1*), in which aqueous dispersions were employed as the medium to effect chain extension of urethane prepolymers. The use of solvent solutions of diisocyanates to improve the strength of latex-treated paper also has been reported (*2*). In addition to the dangers arising from the solvents used, this method requires the use of toxic diisocyanates. By comparison the urethane polymers are relatively nontoxic. When considering the preparation of aqueous dispersions, the reaction of the terminal isocyanate groups of the urethane with water, according to equation (2), must be considered. This reaction results in the formation of polymeric ureas:



$$2\ OCN{-}R{-}NCO + HOH \rightarrow OCN{-}R{-}\underset{\displaystyle H}{\overset{}{N}}{-}\overset{\displaystyle O}{\overset{\|}{C}}{-}\underset{\displaystyle H}{\overset{}{N}}{-}R{-}NCO + CO_2 \quad (2)$$

Table I. Some Properties of Urethane Polymers

	Adiprene[a] *L-100*	*Adiprene*[a] *L-167*	*LD-213*[a]
Specific gravity	1.06	1.06	1.15
Viscosity, 86°F. Brookfield, cp.	14–19,000	6000–8000	12–18,000
Viscosity, 212°F. Brookfield cp.	500–600	250–350	300–400
Isocyanate content, %	4.0–4.3	6.2–6.5	9.2–9.5
Reactivity	Slowest	Intermediate	Fastest

[a] Elastomer Chemicals Dept., E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

In the absence of a catalyst, reaction with water proceeds slowly at room temperature. When catalyzed, e.g., by bases, a rapid reaction is possible at room temperature.

Two methods of dealing with this reaction or of minimizing its effect are: (1) to react the isocyanate groups with a monofunctional compound to "block" or "cap" them, or (2) to prepare emulsions and use them to treat paper before an appreciable reaction with water occurs. In the first case, heat must be used to regenerate the isocyanate groups by reversing urethane formation. However, the number of compounds which will regenerate isocyanate at moderate temperatures is limited. Generally, high temperatures (higher than 300°F.), long heating cycles, or both, are required to complete the reaction. For this reason, the second approach was considered more suitable for paper treatment.

EXPERIMENTAL

The urethane polymers used in this study are reaction products of toluene diisocyanate and polyalkylene ether glycol. They are viscous, honey-colored liquids having excellent room-temperature stability in the absence of moisture. Their properties are given in Table I (ref. 3).

Preparations of Emulsions

The emulsion formulation developed for this work is given in Table II.

The sodium alkyl sulfate is the principal emulsifying agent used in the formulation. Ammonium caseinate, a protective colloid, is included to enhance the emulsion stability and reduce settling. Sodium dioctyl sulfosuccinate, a powerful wetting agent, aids in dispersion of the hydrophobic urethane and assures that the emulsion possesses good wetting power for paper saturation. The nonyl phenoxy polyoxyethylene ethanol used has a hydrophilic–hydrophobic balance at the borderline between oil solubility and water solubility, and improves the emulsifying and wetting power of the other surface active agents. Toluene reduces the viscosity of the urethane polymer and aids in mixing the nonyl phenoxy polyoxyethylene ethanol with the urethane, thereby facilitating emulsification. It also increases the physical stability of the system by reducing the specific gravity of the dispersed organic phase, thereby reducing the settling rate.

The emulsification is carried out at room temperature.

Table II. Urethane Polymer Emulsion (33.3%) Anionic

	Parts by weight
Part A	
Urethane polymer	100
Toluene	50
Nonyl phenoxy polyoxyethylene ethanol[a]	4
Part B	
Sodium alkyl sulfate (10%)[b]	30
Sodium dioctyl sulfosuccinate (5%)[c]	20
Ammonium caseinate (10%)[d]	30
Water	66

[a] Igepal CO-530, Antara Chemicals, General Aniline & Film Corp., New York, N. Y.
[b] Aquarex ME, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.
[c] Aerosol OT, American Cyanamid Co., New York, N. Y.
[d] Sheffield Chemical Co., Norwich, N. Y.

Table III

Color	Chalk white
pH	6.3
Viscosity, cp.	45
Average particle size, μ	5

The urethane polymer and solvent are mixed thoroughly at room temperature followed by the addition of the nonyl phenoxy polyoxyethylene ethanol. The organic phase (Part A) is added slowly over a period of about 2 to 3 min. to the aqueous phase (Part B) while stirring rapidly with a high speed agitator. Either an Eppenbach homogenizer* or a Kady mill† is ideally suited for this purpose. After all the organic phase has been added, the agitation is continued for 5 to 10 min.

This formulation gives a urethane polymer concentration of 33.3%. This can be altered to suit individual requirements by appropriate changes in the amount of water used. The emulsion has the following physical properties after preparation.

Paper Saturation

Emulsions of the urethane polymers were used to saturate $6^1/_2$ by 8-in. sheets of Duracel 301M, a 30 lb. (49 g.s.m.) basis weight, creped, semibleached kraft paper.* Excess saturant was removed by passing the sheets through a pair of metal squeeze rolls, set at 6-mils clearance. The paper was dried for 10 min. at 212°F. and the percentage saturation determined. The per cent saturation was regulated by adjusting the solids content of the emulsion by the addition of water. The term "per cent saturation" as used in this study refers to the per cent of nonvolatile solids introduced into the paper based on the original weight of the dry paper.

Testing Procedures

All saturated papers were stored and tested at 75°F. and 50% R.H. The tests used are outlined below:

Internal Bond or Ply Adhesion. This test measures the internal fiber bonding or delamination resistance of the saturated paper. Two pieces of rug binding tape are heat-sealed on either side of the saturated paper. The tapes are then pulled apart so as to cause a splitting of the paper. The force required to continue splitting is measured on an Instron* tensile testing machine at a rate of jaw separation of 12 in. per min., and is reported as the internal bond, expressed in ounces per inch width (*4*).

* Eppenbach, Inc., Long Island City, N. Y.
† Kinetic Dispersion Corp., Buffalo, N. Y.
* Brown Co., Berlin, N. H.
* Instron Engineering Corp., Quincy, Mass.

Dry Tensile Strength. The dry tensile strength is measured using 1 by 6-in. strips died out on a clicking machine. The papers are tested on an Instron tester at a jaw separation rate of 2 in. per min. (TAPPI Standard T 404 m-50).

Wet Tensile Strength. Samples (1 by 6 in.) died from the same sheet used for dry tensile specimens are immersed in distilled water for 24 hr. at an ambient temperature of 75°F. The wet paper is blotted and then tested in the same manner as for dry tensile strength (TAPPI Standard T 456 m-49).

Water Absorption. Pieces of cured saturated paper (3 by $2^1/_2$ in.) are died from a larger sheet which has been stored for 24 hr. at 75°F. and 50% R.H. The pieces are weighed and then immersed in distilled water for 24 hr. at an ambient temperature of 75°F. Excess surface water is allowed to drain off and the wet paper re-weighed. The water absorption is expressed as the weight per cent of water absorbed based on the dry weight of the paper.

Physical Stability

The emulsion previously described is physically stable for a month or more. A small amount of solids, which may settle after one to two weeks, can be easily re-dispersed with moderate agitation. Emulsions prepared with a lesser amount of toluene exhibit a lesser degree of stability. Solvent-free emulsions can be prepared but begin settling in less than 1 hr. after preparation and are not generally suitable for paper saturation.

Other solvents which are nonreactive with isocyanates, such as xylene, perchloroethylene, or tetrachloro difluoroethane, can be used instead of toluene without affecting the properties obtained from paper treated with these emulsions. However, a generalization cannot be made concerning the use of these other solvents since the physical stability of emulsions prepared with other solvents will not necessarily be equivalent to that obtained when toluene is used. Agglomeration caused by poor stability will cause uneven saturation of a paper sheet with resulting poor appearance and varying properties.

Chemical Stability

As mentioned before, isocyanate end-groups react slowly with water at room temperature. Coagulation of an emulsion which has stood for one day at ambient temperature yields a hard, solid, urea-urethane resin which is quite unlike the original urethane polymer. Since carbon dioxide is evolved in the reaction of an isocyanate with water, pressure will develop if the emulsion is kept in a tightly sealed container. For this reason urethane emulsions should be stored in vented containers.

The polymer formed during the aging of the emulsion as a result of the reaction with water is less effective as a paper saturant than the original low-molecular-weight urethane polymer. Table IV shows the reduction in strength which occurs with increasing emulsion age. No significant loss in strength occurs up to 6 hr. of emulsion aging, but beyond this time a measurable loss in paper strength occurs. One-day aging of the emulsion gives paper with 38% less internal bond strength, 16% less dry tensile strength, and 67% less wet tensile strength compared to a sheet treated with a fresh emulsion. Using a one-month-old emulsion results in internal bond and dry tensile strengths which are only 30% and 68%, respectively, of that obtained using a fresh emulsion. After the emulsion has been aged for one to two weeks, it no longer is effective in imparting wet strength to paper.

The solvent used in preparing the emulsion appears to contribute to its chemical stability as well as its physical stability. If the toluene is omitted from the formulation shown in Table II, the strength imparted to the paper is less than when toluene is used. The greater effectiveness of emulsions containing organic solvents is attributable to a protection of the isocyanate groups from water by the hydrophobic solvent. This solvent protection has been previously observed during studies on interfacial polycondensation (*5*). Evidence for this theory is afforded by the similarity in the strength obtained from a solvent-free emulsion to the strength imparted by a toluene emulsion which has aged for one day. This is shown in Table V.

Table IV. Reduction in Strength with Increasing Emulsion Age

Test specimens: 50% saturation with Adiprene L-100 urethane rubber. Stored for 7 days at 75°F. and 50% R.H. before testing

Emulsion age	*Internal bond, oz./in. width*	*Dry tensile strength, lb./in. width*	*Wet tensile strength, lb./in. width*
Fresh	58	25	18
3 hr.	58	25	18
6 hr.	53	25	18
1 day	36	21	6
7 days	24	18	1
14 days	20	17	0.5
28 days	17	17	0.5
Untreated paper	7	10	0.5

The reaction of the resin with water also explains the poor paper properties obtained from emulsions prepared by the *in situ* or "nascent" soap method, using sodium salts of rosin acids or tall oil as the emulsifiers. Fresh emulsions prepared by this method give paper reinforcement about equal to that obtained with the standard emulsion formulation after 28 days' aging (see Table IV). The alkaline sodium soaps used as emulsifiers catalyze the isocyanate-water reaction and lead to poor chemical stability of the emulsion.

Table V. Strength of Toluene and Solvent-Free Emulsions

Test specimens: 50% saturation with Adiprene L-100 urethane rubber. Stored for 7 days at 75°F. and 50% R.H. before testing

Emulsion type	*Internal bond, oz./in. width*	*Dry tensile strength, lb./in. width*	*Wet tensile strength, lb./in. width*
Toluene (fresh)	58	25	18
Toluene (1 day aging)	36	21	6
Solvent-free (fresh)	35	22	8

Curing of Treated Paper

Water, furnished by atmospheric moisture, has been found to be suitable for curing the urethane polymer. Curing time is dependent on the ambient temperature, polymer reactivity, and the rate of diffusion of

water into the paper. The diffusion rate in turn depends on relative humidity, thickness of the paper, and porosity of the paper.

The porosity of the paper will depend on the construction of the paper and the percentage saturation of the paper.

The curing reaction will proceed as long as moisture and free isocyanate groups are present. Curing will eventually take place in normally humid air at room temperature. Test data in this study were obtained

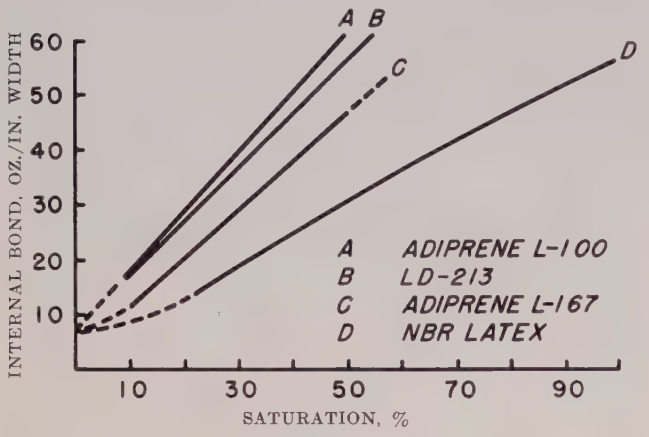


Fig. 1. Internal bond strength of paper saturated with urethane

by the use of 7-day cure at 75°F. and 50% R.H., unless otherwise indicated.

In order to obtain maximum paper strength, the dried saturated paper must be allowed to cure. Paper treated with Adiprene L-100 urethane rubber shows only a slight increase in strength over untreated paper when it is allowed to cure for only one day. Table VI shows the effect of curing time on paper strength properties.

Diamines are generally used to cure liquid urethane elastomers. Curing of saturated paper treated with Adiprene L-100 urethane rubber with MOCA,* 4,4′-methylene-bis (2-chloroaniline), was also tried. The

Table VI. The Effect of Curing Time on Paper Strength Properties

Test specimens: 40% saturation with Adiprene L-100. Stored at 75°F. and 50% R.H.

Cure time, days	*Internal bond, oz./in. width*	*Dry tensile strength, lb./in. width*	*Wet tensile strength, lb./in. width*
Untreated paper	7	10	0.5
1	15	11	17
2	37	22	17
7	42	22	17

MOCA curing agent was added as a dispersion to an Adiprene L-100 emulsion which was used to saturate paper. The diamine-cured polymer was less effective than the moisture-cured polymer in strengthening paper, especially in developing wet tensile strength (Table VII).

The results are believed to be due to a rapid chain extension of the urethane polymer by the diamine, and confirm the results obtained with aged emulsions; namely, that preformed high polymer is less effective in reinforcing paper than lower molecular weight material.

* Elastomer Chemicals Dept., E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

DISCUSSION OF RESULTS

Figure 1 shows the very high degree of internal fiber bonding produced by urethane polymer emulsions. The values are much higher than can be obtained from other elastomeric products now being used. Data from similar paper treated with a butadiene-acrylonitrile latex are also plotted. It can be seen that less than half as much Adiprene L-100 or LD-213 is required

Table VII. Diamine- and Moisture-Cured Polymer

Test specimens: 50% saturation with Adiprene L-100. Stored for 7 days at 75°F. and 50% R.H. before testing

Type of cure	*Internal bond, oz./in. width*	*Dry Tensile strength, lb./in. width*	*Wet Tensile strength, lb./in. width*
Moisture	58	25	18
Diamine	49	22	10

compared to a nitrile latex, to impart a given degree of internal bond strength. Bond strengths could not be measured beyond 60% saturation as the paper was stronger than the test assembly. Failure occurred at the cloth-adhesive interface of the tape, instead of within the paper. The force required for failure varied, but was generally in excess of 100 oz. per in. width, with values as high as 140 oz. per in. width. Of the three urethane polymers tested, the greatest fiber bonding was obtained from Adiprene L-100 urethane rubber followed by LD-213 and then Adiprene L-167. All three polymers, however, produced exceptionally strong paper.

Dry and wet tensile strengths are plotted in Fig. 2. The urethane polymers studied all give equivalent dry tensile strength to paper. At low levels of saturation a small amount of urethane produces a large increase in dry strength. Above 30% saturation the rate of increase diminishes rapidly. In this respect

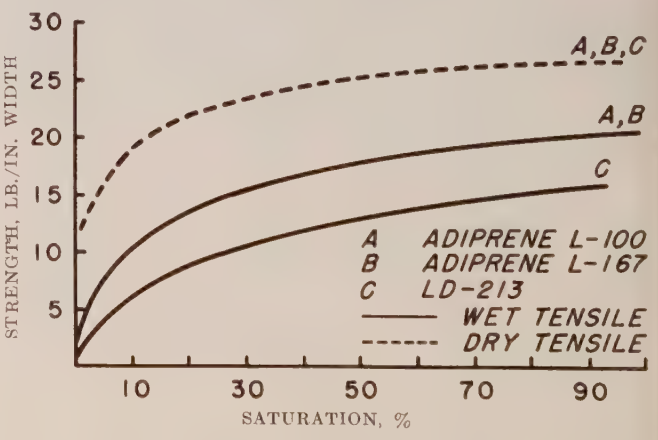


Fig. 2. Tensile strength of paper saturated with urethane

urethane polymers behave like conventional elastomers.

The wet strength of paper saturated with urethane polymer emulsions is outstanding. A wet strength of 70% or more of its dry strength is possible when paper is impregnated with Adiprene L-100. For example, at 50% saturation, paper treated with Adiprene L-100 has a dry strength of 25 and a wet strength of 18 lb. per in. width.

Both Adiprene L-167 and LD-213 contain a higher

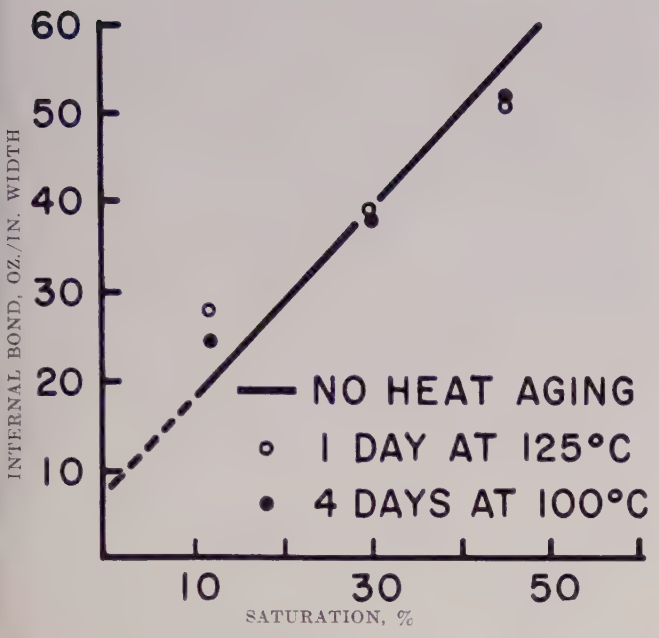


Fig. 3. Internal bond strength of paper saturated with adiprene L-100

concentration of isocyanate groups than Adiprene L-100. It is therefore probable that emulsions of these polymers age more rapidly than Adiprene L-100. This would explain the lower internal bond obtained from Adiprene L-167 urethane rubber and the lower internal bond and wet strength obtained from LD-213.

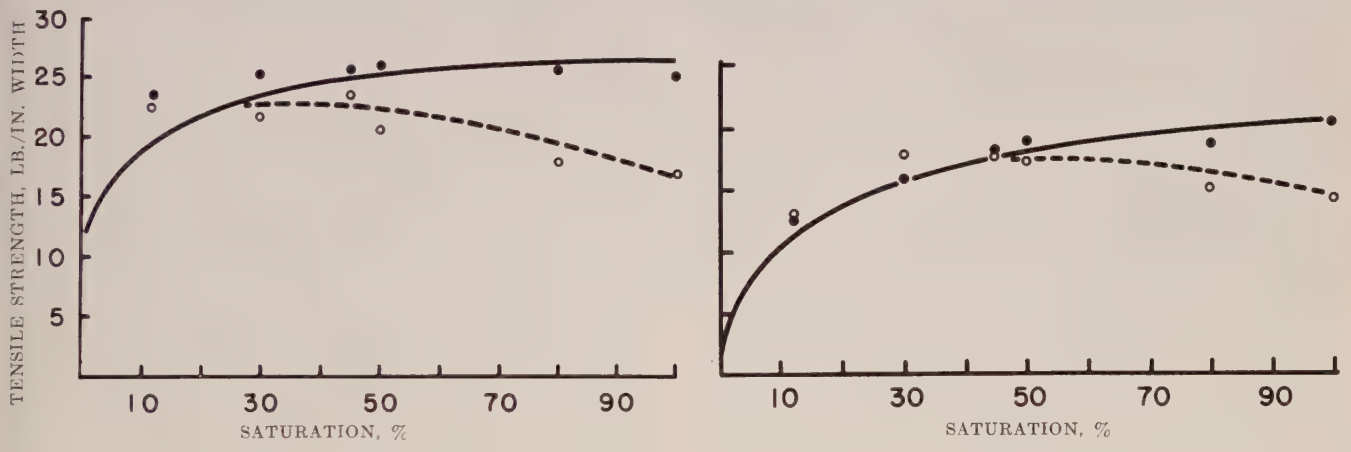
Table VIII. Water Absorption of Saturated Kraft Paper

Saturation, %	*Nitrile treated, wt. % H_2O absorbed*	*Adiprene L-100 treated, wt. % H_2O absorbed*
Untreated paper	170	170
10	132	142
30	105	110
60	90	85
80	85	77

account for the combination of high internal bond and dry and wet strength which is obtained from urethane-treated paper.

Heat-Aging

The internal bond, and dry and wet tensile strengths of paper treated with moisture-cured Adiprene L-100 were determined before and after exposing the paper to dry heat. Figure 3 shows that the internal bond strength of paper is not affected by exposure to 100°C. for four days, or to 125°C. for one day. Dry and wet tensile strength after heat-aging are plotted in Figs. 4 and 5, respectively. Excellent retention of dry and wet strength after exposure to 100°C. for four days is shown. However, loss of dry and wet strength occurs when the saturated paper is exposed at 125°C. for one day. The loss in tensile strength was not apparent at low saturation levels but was detected as the saturation level increased. Measurable loss in dry strength occurred beyond 30% saturation, and above 50% saturation in the case of the wet strength. Degradation of Adiprene L-100 urethane rubber above 100°C.



Figs. 4 and 5. Dry (left) and wet tensile strengths of paper saturated with Adiprene L-100

——No heat aging; ----○----1 day at 125°C.; ● 4 days at 100°C.

It was considered that the high wet strength imparted by the urethanes could be due to the absorption of less water by the treated paper. This was found not to be the case. At the same percentage saturation, it was found that paper treated with Adiprene L-100 absorbed approximately the same amount of water as paper treated with a butadiene-acrylonitrile latex. (Table VIII.)

It is believed that paper treated with Adiprene L-100 resists the effect of water to a much greater extent than papers treated with other elastomers because the sensitivity of the cellulose fibers to water has been reduced by reaction of some of the cellulosic hydroxyl groups with the isocyanate groups of the urethane. The chemical modification of the cellulose fibers would has been observed previously in heat-aging studies of gum vulcanizates (*6*).

Conditions Necessary for Paper Reinforcement

The experimental observations and data presented suggest that in order to develop high strength in paper treated with urethane polymers two conditions must be met: (1) reactive isocyanate groups must be present in the polymer which is used to saturate the paper, and (2) the saturated sheet must be cured, preferably by exposure to water. This can be accomplished by immersion in water or by contact with steam or atmospheric moisture.

Experimental evidence to substantiate the first condition has already been presented in the discussion

of the effect of emulsion age on paper strength. Aged emulsions have had their isocyanate groups deactivated through reaction with water. When an old emulsion is used, a hard, non-film-forming resin, which has no tendency to coat the fibers and is not able to cure into a polymeric network, is deposited in the paper. Reinforcement by reaction of the isocyanate groups with the cellulosic hydroxyl groups also is lost. This case can be likened to attempting to reinforce a fibrous network, such as nonwoven batting, using sand as the binder.

Further evidence was obtained by saturating paper with a fresh emulsion prepared from Adiprene L-100 urethane rubber in which the isocyanate groups were blocked by reaction with *n*-butylamine. After curing for seven days at 75°F. and 50% R.H., these papers showed no increase in internal bond, or dry and wet tensile strength, over untreated paper.

Early experiments (Table VI) indicated the necessity of allowing the saturated paper to cure if maximum strength were to be obtained. Also, paper treated with Adiprene L-100 and stored for seven days over calcium chloride in a desiccator shows only a small increase in strength compared to untreated paper.

From these and other experimental data presented, paper reinforcement with urethane polymers probably occurs as follows. The fluid urethane polymer coats the cellulose fibers. The entire system is then bound together by (a) formation of a high-molecular-weight urethane-urea polymer *in situ* through chain extension with water, and (b) the reaction of some of the free isocyanate groups with cellulosic hydroxyl groups.

SUMMARY

Liquid urethane polymer emulsions can be used to saturate paper. By proper emulsion formulation and prompt application to paper, outstanding internal bond and dry and wet tensile strength can be obtained. Outstanding paper strength is obtained only if reactive isocyanate groups are present in the polymer at the time of saturation, and the polymer in the paper is subsequently cured.

LITERATURE CITED

1. British patent 791,851 (March 12, 1958).
2. Canadian patent 561,061 (July 29, 1958).
3. Athey, R. J., "Chemical Compounding of Liquid Urethane Elastomers," presented before the meeting of the Rubber Division of the American Chemical Society, Los Angeles, Calif., May, 1959.
4. Dunlap, I. R., *Tappi* 40, No. 8: 676–680 (Aug., 1957).
5. Morgan, P. W. and Kwolek, S. L., *J. Poly. Sci.* Vol. 40, 314 (1959).
6. Athey, R. J., *Rubber Age* 85: 77–81 (April, 1959).

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Newsprint from Domestic Timber Bamboo — *phyllostachys bambusoides*

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Pulps from *Phyllostachys bambusoides* for possible use in newsprint-grade papers were prepared experimentally by chemical, semichemical, and mechanical processes. Yields of 82% for cold soda semichemical and 62% for neutral sulfite pulps were realized. Strength characteristics of experimental newsprint from a furnish comprising 80% cold soda and 20% neutral sulfite pulps plus 1% alum, 0.5% rosin, and 7% clay were comparable to those of a control paper from a similar furnish of 80% aspen groundwood and 20% softwood sulfite pulps. Blends of bamboo and wood pulps gave sheets having inferior strength properties in all combinations tried.

Of the 7 million tons of newsprint consumed in the United States during 1959 (*1*) nearly three-fourths was imported, chiefly from Canada. Newsprint papers generally represent pulp blends of about 20 to 30% softwood sulfite and 70 to 80% of coniferous groundwood or chemiground hardwoods. Potential raw materials for manufacture of newsprint pulps include straw, esparto, bagasse, and bamboo. Technical difficulties, as well as economic restrictions, have prevented any of these alternative materials from supplementing wood pulps in the United States. Remoteness of source from processing centers, coupled with harvesting and storage problems, also detracts from the economic usefulness of these fibers. Bamboo is being considered as a potential future farm crop which could be harvested and marketed as a cash crop near pulp mills (*2*).

McClure's suggestion in 1935 (*3*), when he speculated on the industrial potential of bamboo as a crop for the United States, has begun to materialize with developmental studies by the Herty Foundation, Savannah, Ga., and by the Northern Laboratory. Two investigations on bamboo as papermaking raw materials were conducted at Savannah under contract for the Plant Introduction Section, Crops Research Division, Department of Agriculture (*4*). Research at Peoria included preparation of viscose-grade dissolving pulps from *Phyllostachys bambusoides* (*5*), of insulating boards and hardboards also from *P. bambusoides* (*6*), and of newsprint papers—the work reported here.

Bhargava (*7*) about 1944 produced mechanical pulps by grinding three species of bamboo, *Bambusa nutans*, *B. tulda*, and *Dendrocalamus strictus*. Although bleaching the naturally brown pulps was not feasible, zinc hydrosulfite and sodium chlorite appeared the most promising of the several agents tried. The brown-colored pulps were unsatisfactory when blended with 30% bamboo chemical pulp for newsprint.

According to Perdue (*8*) a paper mill in Taiwan is making a Buddhist ceremonial paper, "joss paper," from a blend of rice straw and ground bamboo pulps at the rate of 2 tons per day. *Bambusa stenostachya*,

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Dendrocalamus latiforus, and *Leleba oldhami* are the species used. The paper has low strength characteristics, but is improved by laminating it to a metal foil.

As a result of the studies at the Herty Foundation, Sproull (*9*) concludes that of the various pulping treatments tried with bamboo, mechanical pulping is the least promising. He also believes that difficulties arise because a practical means has not been found to hold culms effectively against the pulpstone, nodes, and internodes differ in physical structure, and hardness changes with drying.

Recently, the Northern Laboratory completed a study of conditions to produce pulps suitable for newsprint from domestically grown *P. bambusoides*.

EXPERIMENTAL

Culms of *P. bambusoides* were obtained from the United States Department of Agriculture's Barbour Lathrop Plant Introduction Garden, Savannah, Ga., in the spring of 1957. These culms were from a random harvest late in 1956 and represented material up to 15 years old. After receipt, the culms were exposed to the weather about one year before actual use. A portion of the culms was chipped with a conventional 2-knife chipper, the chips were screened, and the fraction collected between $^5/_{16}$- and $^3/_4$-in. screens was retained for pulping. Another portion of the culms was cut to 6-in.-lengths for mechanical processing on a pulpstone.

Chemical and Semichemical Pulping

Neutral sulfite chemical pulp from *P. bambusoides* was made in the following manner: Approximately 300 g. of airdry chips were placed in a 2-liter stainless-steel digester with sufficient solution of sodium sulfite (73%) and sodium carbonate (27%) to make a liquid-solids ratio of 5:1. The total chemical, based on moisture-free chips, was 22%. Heating was for 5 hr. at 170°C. The cooked chips were defibered in a laboratory beater to a S.-R. freeness of 230 ml. (40 min.), and the resulting pulp was bleached in three stages:

1. Chlorine, 25°C., 90 min., Cl_2-12%, consistency 2%.
2. Caustic soda, 70°C., 60 min., NaOH-2%, consistency 3%.
3. Hypochlorite, 40°C., 240 min., Cl_2-5%, consistency 3%.

An 8-in. single-disk refiner set with 0.002-in. clearance was used in some instances instead of a laboratory beater.

Cold soda semichemical pulps were made similarly—the liquid-solids ratio, 5:1 and the amount of caustic soda applied, 18 to 22%, basis moisture-free chips. Steeping was facilitated by the application of 150 p.s.i. hydrostatic pressure. Steeped chips were defibered in a disk mill before further treatment in a vertical refiner or in a laboratory beater. Pulps were also bleached in three stages as described.

Larger quantities of the neutral sulfite and cold soda pulps were prepared by using a 10-gal. stainless-steel digester for the initial treatments. All refining was performed with the single-disk mill. Bleaching was done in a single stage with sodium hypochlorite for 240 min. at 55 to 60°C. and pH 9.5 to 10.5. In the cold soda treatment the amount of sodium hydroxide applied was increased to 26.6%.

Mechanical Pulps. Grinding of bamboo was performed at the U. S. Forest Products Laboratory,

Table I. Characteristics of Bamboo Pulps for Newsprint Service

Pulp No.	Material and treatment	Amount of chemical applied,[a] %	Time, hr.	Liquid-solids ratio	Refining[b]	Bleach treatment	S.-R. freeness, ml.	Brightness Hunter, %	Final yield, %	Physical properties of handsheets — Basis weight[f] (25×40-500), lb.	g.s.m.	Caliper, mils	Density, g./cc.	Burst factor, g./cm.²/g.s.m.	Tear factor, g./g.s.m.	Breaking length, m.	Fiber-size classification — Plus 80 mesh, %	80–100 mesh, %	100–150 mesh, %	150–200 mesh, %	Passing 200 mesh, %
	Bamboo, neutral sulfite chemical																				
1	73% $NaSO_3$ at 170°C.	22.0	5.0	5:1	10-B	None	800	...	65	47.4	66.7	4.9	0.535	28.2	86.8	4700					
2					40-B	None	230	...	65	47.2	66.4	3.0	0.870	37.8	33.8	7015					
3					40-B	12-2-5[c]	230	63.6	65	42.8	60.2	2.4	0.486	29.8	31.9	5870					
4	27% Na_2CO_3				2 passes-D	None	900	25.0	62	40.2	56.5	4.8	0.463	10.6	82.7	2305					
5					2 passes-D	15[d]	...	67.0	62	46.4	65.3	5.1	0.502	17.3	83.2	3780	53.5	3.0	2.8	4.2	36.5
	Bamboo, cold soda semichemical																				
6	NaOH at 25°C., 150 p.s.i.	18.0	0.50	3 3:1	1 pass-D, 8-V	4-2-5[c]	670	29.3	80	47.0	66.1	6.5	0.400	4.7	16.0	1200					
7		22.0	0.75	3:1	1 pass-D, 60-B	None	450	28.2	85	49.1	69.1	6.2	0.438	6.4	16.7	1575					
8		22.0	0.75	3:1	1 pass-D, 60-B	12-2-6	...	43.6	85	47.5	66.8	3.5	0.750	5.4	29.0	1000					
9		26.6	16.0	4.5:1	Recycle through D to pass 6 cut screen	None	730	29.3	82	46.3	65.1	5.7	0.499	8.4	39.3	1945					
10		26.6	16.0	4.5:1		15[d]	780	50.4	82	50.4	70.9	6.3	0.442	9.9	45.2	2200	66.0	6.5	7.7	6.3	13.5
11	Bamboo, chemiground 84% $NaSO_3$ 16% $NaHCO_3$ at 150°C.	10.9	1.0	4:1	P	14[d]	770	44.1	...	37.7	53.0	5.4	0.26	3.1	31.7	1090	44.4	3.4	7.2	8.8	36.2
12	Wood Softwood sulfite, commercial[e]	...	...	...	Unbeaten	...	885	50.6	...	45.6	64.1	4.2	0.650	5.5	70.0	1147	89.7	2.4	2.4	2.7	2.8
13	Aspen groundwood. commercial type[e]	...	...	...	...	...	380	60.6	...	45.4	63.9	4.9	0.512	14.5	30.1	3446	45.6	7.4	11.7	6.3	29.0

[a] Basis moisture-free material.
[b] Time in min. or number of cycles in designated equipment; B = beater; D = disk mill; V = vertical refiner; P = pulpstone.
[c] Three-stage: chlorine, caustic soda, and sodium hypochlorite, %.
[d] Single-stage: sodium hypochlorite, %.
[e] Pulps furnished by U. S. Forest Products Laboratory, Madison, Wis.
[f] Conditioned basis: 23°C., 50% R.H.

Madison, Wis., with a 3-pocket grinder having a 54-in. diam., no. 60 grit pulpstone with an 8-in. face. Only one pocket was used in these studies. Airdry and water-saturated culms were tried on the stone, but the ground products were like very fine flours rather than fibrous pulps. Consequently, pretreatments with sodium sulfite-carbonate solutions at 120 and 150°C. were employed to soften the culms before grinding on the pulpstone. Only the pulp involving pretreatment at 150°C. was bleached, using 14% sodium hypochlorite expressed as available chlorine.

Data. Conditions for the preparation of chemical, semichemical, and mechanical bamboo pulps and their physical characteristics, as determined from handsheets according to TAPPI Standard Methods, are summarized in Table I. Characteristics of two wood pulps, one a commercial unbleached softwood sulfite and the other aspen groundwood, are also presented in Table I. These wood pulps were obtained as controls and were used in preparing newsprint blends.

Machine Papers. Three experimental bamboo pulps and the two wood pulps were used to make furnishes run on a 10-in. fourdrinier machine. Furnishes were composed of 20% chemical-type pulp and 80% mechanical-type plus 0.5% rosin, 1.0% alum, and 7.0% clay. All furnishes were run at 0.2% consistency and at a machine speed of 5 f.p.m. Sheets were calendered lightly, then conditioned and tested according to TAPPI Standard Methods. Properties of five experimental papers and published data for typical commercial newsprint are given in Table II.

Table II. Properties of Machine Papers from Combinations of Bamboo and Wood Pulps Plus Size and Clay Filler

Blend	Pulps blended[a] Chemical 20% No.	Mechanical 80% No.	S.-R. freeness, ml.	Basis weight (25 × 40-500), lb.	g.s.m.	Caliper, mils	Density, g./cc.	Burst factor, g./cm.²/g.s.m.	Tear factor, g./g.s.m. MD	CD	Breaking length, m MD	CD	Brightness, Hunter, %	Opacity, %	Porosity, sec. 100 cc.
A	5 NS	10 CS	780	38.6	54.3	4.2	0.508	8.6	38.9	49.6	2408	1754	58.0	95.9	<1
B	5 NS	11 CG	830	49.4	69.5	7.0	0.390	1.7	14.7	18.4	483	158	46.5	89.1	<1
C	5 NS	13 GW	450	41.3	58.1	6.7	0.507	8.0	23.2	28.7	2034	1448	64.7	96.6	31
D	12 S	10 CS	820	41.9	58.9	5.4	0.445	4.9	32.6	52.2	1381	838	57.2	90.2	<1
E	12 S	13 GW	480	37.9	53.3	4.0	0.524	9.1	42.0	51.6	2275	1564	61.2	96.3	33
Typical newsprint[b]			...	38.0	53.5	3.3	0.64	12.5	av. 38.4		av. 2838		58	92	52
Standard sample[c]			...	36.4	51.2	2.7	0.746	11.0	38.7	43.7	2560	1370	45.8	92.9	11

[a] See Table I for description of pulp preparation and properties. NS = neutral sulfite bamboo; CS = cold soda bamboo; CG = chemiground bamboo; S = softwood sulfite; and GW = groundwood.
[b] Commercial data for more than 50 commercial newsprints (*11*).
[c] Newsprint meeting Government Paper Specification Standards (*10*).

DISCUSSION

Bamboo chips cooked at 170°C. by the neutral sulfite process were readily defibered by two passes through the single-disk mill with 0.002-in. clearance between dull grid-type plates. Breaking length and burst factor for handsheets from bleached pulps at nearly comparable levels of brightness were less for pulp (no. 5) refined in the disk mill than for pulp refined in the beater (no. 3) (5870 vs. 3780 m. and 29.8 vs. 17.3, respectively) although tear factor for the no. 5 pulp was higher (83.2 vs. 31.9). Similarly, comparing unbleached pulps of roughly the same freeness, the breaking length and burst factor were much lower for the pulp refined in the disk mill (no. 4) than for the pulp refined in the beater (no. 1) while the tear factor was about the same. Compared with their unbleached counterparts, pulps bleached by the single-stage hypochlorite treatment exhibited increased strength (no. 5 vs. no. 4); whereas pulps bleached in three stages showed some loss of strength (no. 3 vs. no. 2). Bleached neutral sulfite bamboo pulp (no. 5) had strength properties superior to the unbeated softwood sulfite pulp used in this study for control and blending (no. 5 vs. no. 12) even though there was a substantially greater amount of long fibers in the woodpulp.

In the preparation of a semichemical pulp from bamboo by the cold soda treatment, complete penetration of all chips required a period in excess of 45 min. but less than 16 hr. The minimum required time was not determined. Unlike the no. 5 pulp, the cold soda bamboo pulp (no. 10) refined in the disk mill was stronger than those refined in the beater. Strength changes on bleaching cold soda pulps were similar to those observed for the neutral sulfite pulps; the three-stage treatment caused loss of strength (no. 8 vs. no. 7), and the single-stage hypochlorite treatment caused some improvement (no. 10 vs. no. 9). Approximately 50% of the chemical was consumed or otherwise unaccounted for in the cold soda treatment. The yield of this pulp was approximately 82%, which should favor its consideration as the mechanical component in newsprint furnishes if strength characteristics are acceptable. The indications are, however, that cold soda bamboo pulp might be too weak for use as a replacement.

The chemiground bamboo pulp (no. 11) was comparable in tear strength to the aspen groundwood (no. 13) but was substantially weaker in burst and tensile, although the distribution of fiber sizes in both the bamboo and wood pulps was in reasonably close agreement (no. 11 vs. no. 13).

Machine papers indicate that blend A of neutral sulfite bamboo and cold soda semichemical pulps has properties most nearly like those of the all-wood control sheets, blend E. All data, with the exception of burst, are in reasonable agreement with average data on more than 50 commercial newsprints and that for a newsprint procured under Government Paper Specification Standards JCP-A10 (*10*). Blend B, chemiground bamboo with neutral sulfite bamboo, and blend D, cold soda bamboo with softwood sulfite pulp, failed to approach strength requirements. Blend C, neutral sulfite bamboo pulp with aspen groundwood pulp, was an improvement over blends B and D, but was also deficient strengthwise. Thus, present data indicate that an all-bamboo newsprint-type paper can be made from a 20 : 80 blend, no. A, of neutral sulfite chemical and cold soda semichemical bamboo pulps. The present study failed to show compatibility between bamboo and wood pulps. Three of the machine papers involving blends of bamboo exhibited a high degree of porosity although blend C (chemical bamboo and aspen groundwood

pulps) had a porosity value comparable to that of an all-wood sheet.

SUMMARY

Culms from domestically grown timber bamboo, *Phyllostachys bambusoides*, up to 15 years old, have been used to prepare chemical, semichemical, and mechanical pulps for newsprint grade papers. Yields of 82% for cold soda semichemical and 62% for neutral sulfite pulps were realized. Stone grinding with and without chemical pretreatment failed to produce satisfactory pulps from the mature culms. Strength characteristics of experimental newsprint from a furnish comprising 80% cold soda and 20% neutral sulfite pulps 1% alum, 0.5% rosin, and 7% clay were comparable to those of a control paper from a similar furnish of 80% aspen groundwood and 20% unbeaten softwood sulfite pulps run on the same laboratory fourdrinier machine. Blends of bamboo and wood pulps gave sheets having inferior strength properties in all combinations tried.

This limited study indicates that dried mature timber bamboo (*Phyllostachys bambusoides*) might be used to some extent in newsprint-type papers. Further investigation with respect to treatment prior to grinding and to use of green bamboo, and more extensive study of variables in preparation of both chemical and mechanical pulps and of machine furnishes might indicate preferred treatments as well as lead to end products superior to those reported here.

LITERATURE CITED

1. Anonymous, *Pulp and Paper* 34, No. 8: 163 (July 10, 1960).
2. Sturkie, D. G., *Crops and Soils* 12, No. 4: 12–13 (January, 1960).
3. McClure, F. A., *Sci. Monthly* 41: 193–204 (September, 1935).
4. Final reports from Herty Foundation Laboratory, Savannah, Ga., to Crops Research Division, United States Department of Agriculture, Washington, D. C., on research contracts No. A-1s-33720 (completed May, 1955) and No. A-1s-33976 (completed May, 1956).
5. Naffziger, T. R., Matuszewski, R. S., Clark, T. F., and Wolff, I. A., *Tappi* 43, No. 6: 591–596 (June, 1960).
6. Naffziger, T. R., Clark, T. F., and Wolff, I. A., *Tappi* 44, No. 2: 108-112 (Feb., 1961).
7. Bhargava, M. P., *Indian Forest Bull.* No. 129, Forest Research Institute, Dehra Dun, U. P. (1946).
8. Perdue, R. E., Jr., private communication. Botanist, Crops Research Division, Agricultural Research Service, Beltsville, Md. (Feb. 9, 1960).
9. Sproull, R. G., *Tappi* 38, No. 10: 593–596 (October, 1955).
10. Joint Committee on Printing, Congress of the United States, "Newsprint" in *Government Paper Specification Standards*, JCP A10, Washington, D. C., U. S. Government Printing Office (July 1, 1960).
11. Chidester, G. H., Seidl, R. J., and Schafer, E. R., "Experiments in the Manufacture of Newsprint from Cotton and Willow," Report No. 2028, p. 17, Madison, Wis., U. S. Forest Products Laboratory (March, 1955).

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Studies on the Barks of the Family Salicaceae

IV. Preliminary Evaluation for Glucosides of Barks of Several Species of the Genus Populus

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The barks of six *Populus* species of importance to the pulp and paper industry were extracted with hot water, and the hot-water extracts were clarified by treatment with basic lead acetate, freed of lead, and concentrated. These concentrated solutions were examined for their glucoside- and phenolic-compound content by solvent fractionation and by chromatographic and countercurrent distribution techniques. Salicin was found to be present in all barks studied and salireposide in all but one. Tremuloidin was found only in the barks of *P. tremuloides* and *P. grandidentata*. These same two barks were the only ones tested that yielded large quantities of extractives and appeared to be the only two barks suitable for large-scale glucoside isolation studies. Paper chromatography of all bark extracts indicated the presence of many as yet unknown glucosides, and some appeared to be present in substantial amount. In addition, many phenolic compounds were found in the extractives. The presence of these phenolic compounds suggest that glucosides or glucoside esters of these compounds might be present in the hot-water extractives of these barks.

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IN EARLIER papers the isolation from the bark of American quaking aspen (*Populus tremuloides*) of salicin, salireposide, a new glucoside, tremuloidin, and other glucosides was reported (*1*, *2*). The finding of tremuloidin in the American quaking aspen bark instead of its isomer, populin, which is present in the bark of the European quaking aspen (*P. tremula*) (*3*) led to an investigation of the glucoside content of barks of other American *Populus* species. The present paper reports preliminary results obtained on the investigation of the barks of several American *Populus* species of importance to the pulp and paper industry. The barks investigated in this study comprised *P. tremuloides*, *P. grandidentata* (bigtooth aspen), *P. tacamahaca* (balsam poplar), *P. heterophylla* (swamp cottonwood), *P. deltoides* (cottonwood), and *P. trichocarpa* (northern black cottonwood).

All finely divided barks were extracted with boiling water, and the aqueous extracts were purified by treatment with excess basic lead acetate and filtering off the lead salts of interfering materials. The filtrates were freed of lead by precipitation with hydrogen sulfide and filtering. The clarified filtrates were concen-

Table I. Qualitative Evaluation of Barks for Known Glucosides and Phenolic Compounds

Compounds	10:3:3 Rf[a]	8:2:1 Rf[a]	*Populus tremuloides*	*P. grandidentata*	*P. tacamahaca*	*P. heterophylla*	*P. trichocarpa*	*P. deltoides*
Salicin	0.52	0.59	+	+	+	+	+	+
Tremuloidin	0.77	0.80	+	+	−	−	−	−
Populin	0.69	0.79	−	−	−	−	−	−
Salireposide	0.68	0.73	+	+	−	+	+	+
Salicyl alcohol[b]	0.86	0.88	+	+	+	+	+	+
Gentisyl alcohol[c]	0.77	0.88	+	+	+	+	+	+
p-Hydroxybenzoic acid[bd]	0.56	0.82					+	
p-Coumaric acid[bd]	0.57	0.81	+	+	+		+	
Vanillic acid[bd]	0.44	0.77		+			+	
Syringic acid[bd]	0.38	0.69				+	+	
Vanillin[b]	0.83	0.89					+	

[a] Rf values are for the 10:3:3 butanol–pyridine–water and 8:2:1 ethyl acetate–pyridine–water systems at 25°.
[b] Phenolic compounds were identified qualitatively by their Rf values and by color reactions with several stabilized diazo reagents (7).
[c] Gentisyl alcohol identified by color reaction with diazo reagents and by immediate appearance of a black spot when developed chromatogram is dipped in silver nitrate solution before treatment with alkali.
[d] Phenolic acids were also separated on paper chromatograms by development in butanol saturated with 2% aqueous ammonia and benzene saturated with formic acid systems noted earlier (8).

trated and extracted exhaustively with ethyl acetate. The ethyl acetate extracts were examined for glucoside content by solvent fractionation and by chromatographic and countercurrent distribution procedures reported in earlier papers (*1*, *2*, *4*, *5*). Preliminary identification of materials was made by means of paper chromatography. In most cases, however, materials were present in sufficient quantity so that identity could be confirmed by isolation and subsequent mixed melting point and identity of infrared absorption spectrum with authentic products.

EXPERIMENTAL

Materials

The bark samples employed in this investigation were those described in detail in another study on the alkaline hydrolysis of *Populus* species barks (*6*).

General Glucoside Extraction Procedure

All extractions were made in the same manner on finely divided bark samples. Approximately 1500 g. of bark (ovendry basis) was suspended in 10 liters of water, and the mixture was heated to boiling with occasional stirring. The hot mixture was filtered with suction through cloth, and the residue was reheated with 10 liters of water. This mixture was filtered, and the residue squeezed dry. The combined filtrates were treated with stirring with an excess of a slurry of basic lead acetate. The precipitated lead salts were filtered through a Celite pad with the aid of Celite filter aid. The clear filtrate was saturated with hydrogen sulfide at room temperature, heated to boiling to remove excess hydrogen sulfide, and filtered hot through a Celite pad. The almost colorless clear solution was concentrated to approximately 1000 ml. volume in a laboratory circulating evaporator under reduced pressure. The concentrated aqueous extract was extracted exhaustively with ethyl acetate in a nonagitated liquid-liquid extractor. Ethyl acetate extracts were examined qualitatively by paper chromatography in the 10:3:3 butanol–pyridine–water and 8:2:1 ethyl acetate–pyridine–water systems and spots were located by means of a modified silver spray (*1*) and the diazotized *p*-nitroaniline spray (*2*) reported earlier. Known glucosides and phenolic materials identified in these extracts are given in Table I. It should be noted that the glucosides of Table I were tested for specifically, and a negative sign in the table indicates that the compound is absent. On the other hand, the phenolic compounds indicated by a positive sign in Table I are those compounds which were identified on the chromatograms during the course of the study. These compounds were not sought specifically, and failure to appear as positive marks in Table I indicates only that they were not recognized on the chromatograms and not that the compounds are positively absent.

Further fractionation and isolation of products are noted under each individual bark species.

Populus tremuloides

During the concentration of the purified aqueous extract before ethyl acetate extraction, crystals of tremuloidin separated. These were filtered and identified by mixed melting point with authentic tremuloidin (*1*). The ethyl acetate extract of the concentrated aqueous solution was evaporated to dryness in a rotating vacuum evaporator. The residue was taken up in water and extracted with ether. The ether removed more tremuloidin from the aqueous solution, and, on further concentration, the aqueous solution deposited salireposide and finally salicin. Salireposide and salicin were identified by melting point and mixed melting point with authentic samples (*1*, *2*). Paper chromatography of the ether and aqueous fractions indicated a great many compounds giving silver spots and/or spots with diazotized *p*-nitroaniline indicating a variety of glucosidic material. The original concentrated aqueous solution after ethyl acetate extraction was concentrated further to give a heavy precipitate of crystalline salicin. Qualitative paper chromatography of this same concentrated aqueous solution for sugars by procedures referred to in the past (*9*, *10*) and in the 9:2:2 ethyl acetate–acetic acid–water system indicated the presence of sucrose, glucose, fructose, mannose, galactose, and two oligosaccharides with R_f's 0.07 and 0.20 in the ethyl acetate–acetic acid–water developer.

Populus grandidentata

In this instance the concentrated clarified aqueous extract was first extracted with ethyl acetate by shaking in a separatory funnel. The ethyl acetate extract was evaporated to dryness and triturated with water to leave crystalline tremuloidin as a residue. The aqueous solution obtained was concentrated somewhat to yield crystals of salireposide. Further extraction of the original aqueous extract with

ethyl acetate in the continuous liquid-liquid extractor yielded an extract from which only salicin could be isolated as an identifiable substance. However, paper chromatography indicated many glucosides and phenolic materials. Accordingly, a sample of ethyl acetate extractives from which much of the salicin, tremuloidin, and salireposide had been removed was distributed between ethyl acetate and water on a 60-tube 10 ml. per 10 ml. Craig countercurrent distribution machine. Tremuloidin, salireposide, and salicyl alcohol were isolated in separated fractions. In addition, tubes 16 to 25 yielded a crystalline material melting at 210 to 211° with gas evolution. This product had an R_f of 0.76 to 0.78 in the butanol–pyridine–water developer and gave a blue color with diazotized *p*-nitroaniline spray reagent. This blue color faded rapidly to a light gray. Hydrolysis of this product with *N* HCl yielded a phenolic compound and two sugars which appeared to be glucose and arabinose. Thus, the compound melting at 210–211° appeared to be a glycoside of a phenolic material with arabinose and glucose. This compound will be studied further.

As in the case of *P. tremuloides*, the original concentrated aqueous solution after ethyl acetate extraction was concentrated further to give a heavy precipitate of crystalline salicin. Again, this solution was found by chromatography to contain sucrose, glucose, fructose, mannose, galactose, and two oligosaccharides.

Populus tacamahaca

The total yield of solids in the concentrated clarified hot-water extract of this bark was much less than in the cases of the two previous barks. Paper chromatography indicated only salicin as a known glucoside. The ethyl acetate extract was concentrated to dryness in a rotating evaporator, and the residue was distributed between *n*-butanol and water in the Craig machine. Crystalline salicin was obtained by concentration of the first 30 tubes. The contents of tubes 31 to 60 were recombined and distributed between ethyl acetate and water in the Craig machine. Salicyl alcohol was obtained from tubes 44 to 48, and gentisyl alcohol was obtained from tubes 24 to 36. These were identified by melting point and paper chromatography along with authentic samples. Paper chromatography also indicated several unknown glucosides and phenolic compounds.

Populus heterophylla

Of all the *Populus* species barks investigated, this was the only brown and deeply furrowed sample. All the others were green or gray and smooth. The sample employed was a mixture of both inner and outer bark. The hot-water extraction gave a very dark mahogany-colored extract, but the basic lead acetate purification step removed all colored impurities to yield a pale yellow extract. The total yield of solids in the clarified hot-water extract was low compared with the yields from the barks of *P. tremuloides* and *P. grandidentata*. In addition, the ethyl acetate extractives were low in yield. The ethyl acetate extract was dissolved in water and the aqueous solution was extracted continuously with ether. Concentration of the residual aqueous solution yielded crystals of salicin. The ether extract was evaporated to dryness and distributed between ethyl acetate and water in the 60-tube Craig countercurrent distribution machine. The contents of tubes 16 to 19 yielded crystals of salireposide on concentration. Mother liquors from crystallization of the salireposide deposited colorless crystals which were recrystallized from dilute methanol to give crystals melting at 210 to 212°, having a 10:3:3 butanol–pyridine–water R_f 0.78, and giving with diazotized *p*-nitroaniline a blue color fading to a light gray. This compound appears to be identical with that isolated from *P. grandidentata*, but no hydrolysis studies were made on this compound.

Tubes 20 to 26 yielded considerable material from which no crystals could be obtained. The mixture gave a bright orange spot with diazotized *p*-nitroaniline with the following R_f values: 10:3:3 butanol–pyridine–water, 0.85; 9:2:2 ethyl acetate–acetic acid–water, 0.81; and 8:2:1 ethyl acetate–pyridine–water, 0.83. The material on chromatograms, when located by means of the modified silver spray (*1*) gives a black spot before treatment with alkali. The material also gives a positive test for a catechol derivative when treated in aqueous solution with ferric chloride followed by sodium carbonate. Acid hydrolysis produced no sugar. No further characterization of this material was made.

Paper chromatography of various fractions indicated the presence of several unknown glucoside materials and a number of unidentified phenolic compounds. In addition, the presence of nonsugar, nonphenolic, silver-reducing substances was indicated.

Populus trichocarpa

This bark also yielded relatively small amounts of total hot water-soluble material after clarification. The ethyl acetate extract was evaporated to dryness and dissolved in water. The aqueous solution was extracted continuously with ether. Concentration of the residual aqueous solution yielded crystals of salicin. The concentrated aqueous solution was distributed between water and ethyl acetate on the 60-tube Craig machine. Tubes 29 to 47 yielded crystals of salireposide. Tubes 12 to 20 gave a noncrystalline material which gave phenolic glucoside spots with R_f's 0.67 and 0.76 in the butanol–pyridine–water system. Both spots gave blue colors with diazotized *p*-nitroaniline. Preliminary attempts to separate these two materials failed. The mixture was hydrolyzed with emulsin, and the hydrolyzate was chromatographed to indicate glucose, salicyl alcohol, and three unidentified phenolic compounds. Tubes 21 to 28 yielded a sirup which gave a dark crystalline mass on evaporation under reduced pressure. Attempts to recrystallize this material failed but sublimation at 80°C. and 10 mm. Hg pressure yielded colorless plates which were recrystallized from ether–petroleum ether to give crystals melting at 95–96°C. This product was soluble in ether and in water, decolorized aqueous permanganate solution, but not bromine water. The compound has a butanol–pyridine–water R_f of 0.78 and gives a strong spot with the silver reagent, but nothing with the diazo spray reagent. Infrared absorption spectral data indicate an aliphatic hydroxy compound, probably a polyhydric alcohol.

The bulk of the water-soluble material comprising

the contents of tubes 0 to 11 was redistributed on the Craig machine between *n*-butanol and water, and the separation was monitored by means of paper chromatography. Paper chromatography indicated that the mixture was separated effectively into its components by this distribution but the several phenolic compounds were present in too minute quantity for adequate identification. Salicin was isolated as crystals from tubes 17 to 33.

The original ether-soluble fraction was evaporated to dryness and extracted with hot benzene. Cooling of the benzene yielded crystals of salicyl alcohol which were removed by filtration. The benzene was removed under reduced pressure, and the residue was dissolved in ether and extracted with saturated sodium bicarbonate solution. The ether solution was chromatographed to yield salicyl alcohol, gentisyl alcohol, and vanillin which were identified by comparison with authentic samples. The bicarbonate extract was acidified and extracted with ether. The ether solution was chromatographed to yield syringic, *p*-hydroxybenzoic, *p*-coumaric, and vanillic acid, all of which were identified by comparison with authentic samples.

The original aqueous solution after ethyl acetate extraction was chromatographed for sugars and found to contain glucose, galactose, and a little arabinose.

Populus deltoides

The yield of desired glucoside-containing material was very low in this bark. No crystalline products were obtained during the analysis of this bark by chromatographic, countercurrent distribution, and solvent fractionation techniques. Even salicin could only be demonstrated by paper chromatographic procedures. The compounds noted in Table I were found in pure fractions by the several fractionation techniques noted, but always in quantity much too small for isolation in crystalline form. In addition to the compounds in Table I, a number of unidentified phenolic materials and glucosidic compounds were noted by paper chromatography.

DISCUSSION OF RESULTS

Salicin appears to be the major glucoside component of the barks of the several *Populus* species investigated. Only in the instance of *P. deltoides* did the concentrated aqueous extract fail to yield crystalline salicin. All species studied were specifically examined for populin, but no populin could be found in the hot-water extractives of any of the six common American *Populus* species barks. On the other hand, tremuloidin, the isomer of populin, was found in the barks of *P. tremuloides* and *P. grandidentata*. Of the glucosides known to be present in *Populus* species barks, salireposide appears to be almost as general as salicin, being present in five of the six barks studied. *P. tremuloides* and *P. grandidentata* barks are suggested as good raw materials for laboratory preparation of this glucoside.

The apparent yields of total hot-water-soluble materials after evaporation of the clarified extracts cannot be correlated with the yields of ether extractives obtained from the alkaline hydrolyzates of these same barks (*6*). Although *P. tremuloides* and *P. grandidentata* barks give high yield of extractives under both conditions, *P. trichocarpa* and *P. tacamahaca* give high yields of extractives after alkaline hydrolysis, but very low yield of glucoside extractives directly.

It is interesting to note that *p*-coumaric acid was found as a component of the hot-water extractives of those barks which also yielded large amounts of this acid upon alkaline hydrolysis. It is possible that much of this acid is present in the form of glucosides or associated ester materials, and its presence in the original hot-water extract is due to hydrolysis of these materials in the bark itself and also during the laboratory processing. This situation also applies to the presence of salicyl alcohol and gentisyl alcohol in all hot-water extracts since these alcohols would be formed by hydrolysis of salicin and salireposide, respectively. The finding of gentisyl alcohol, but not salireposide, in the hot-water extractives of *P. tacamahaca* bark suggest that this bark, and probably others, contain one or more other glucosides of gentisyl alcohol.

The substantial yields of vanillic, syringic, *p*-hydroxybenzoic, and ferulic acids in the alkaline hydrolyzates of these barks (*6*) indicate the possibility of occurrence of glucosides of these acids or of esters of glucosides. It should be noted that the bark of *P. grandidentata*, upon alkaline hydrolysis, yielded more syringic acid than any other bark of the *Populus* species (*6*), but no syringic acid was found in the hot-water extractives of this same bark sample. If the syringic acid in *P. grandidentata* bark does occur as an ester of a glucoside material, it appears to be very stable toward hydrolysis during processing. The occurrence of glucosides of vanillic and syringic acids in the wood of deciduous trees has been proposed in the past (*11*).

The preliminary studies reported in this paper have led to more intensive studies of these bark extracts, and results of these studies will be published in forthcoming papers.

SUMMARY

Hot-water extracts of the barks of six *Populus* species of importance to the pulp and paper industry were evaluated for their glucoside and phenolic compound content by solvent fractionation and by chromatographic and counter-current distribution techniques. The presence of many known and unknown glucosides and phenolic compounds was demonstrated.

LITERATURE CITED

1. Pearl, I. A. and Darling, S. F., *J. Org. Chem.* 24: 731 (1959).
2. Pearl, I. A. and Darling, S. F., *J. Org. Chem.* 24: 1616 (1959).
3. Braconnot, H., *Ann. Chim. Phys.* [2] 44: 296 (1830).
4. Pearl, I. A., Beyer, D. L., and Dickey, E. E., *J. Org. Chem.* 23: 705 (1958).
5. Pearl, I. A. and Beyer, D. L., *J. Org. Chem.* accepted for publication.
6. Pearl, I. A., Beyer, D. L., Laskowski, D., and Whitney, D., *Tappi* 43: 756 (1960).
7. Pearl, I. A. and McCoy, P. F., *Anal. Chem.* 32: 1407 (1960).
8. Pearl, I. A., Beyer, D. L., Johnson, B., and Wilkinson, S., *Tappi* 40: 374 (1957).
9. Pearl, I. A. and Beyer, D. L., *Tappi* 40: 45 (1957).
10. Pearl, I. A. and Beyer, D. L., *Forest Prods. J.* 9: 381 (1959).
11. Pearl, I. A., Beyer, D. L., and Laskowski, D., *J. Org. Chem.* 24: 443 (1959).

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Studies on the Chemistry of Aspenwood

XV. Further Studies on the Oxidation of Aspen Lignosulfonates with Alkaline Cupric and Silver Oxides

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Quantitative studies were made on the oxidation of fermented aspen spent sulfite liquor by means of alkaline cupric oxide and alkaline silver oxide with varying reactant ratios and cooking conditions. The overall yields of ether-soluble "acids and phenols" were determined, and the yields of individual oxidation products were also reported along with methoxyl data for all fractions and isolated materials. *p*-Coumaric acid was found as an oxidation product in all cupric oxide oxidations, but no ferulic acid whatsoever was found. On the other hand, all silver oxide oxidations yielded ferulic acid, but no *p*-coumaric acid whatsoever. All cupric oxide oxidation conditions yielded *p*-hydroxybenzaldehyde as a product, but, except for one instance, this aldehyde was absent in all silver oxide oxidations. Silver oxide oxidations resulted in degradation of a substantial portion of the starting lignosulfonate material, and model studies on vanillic and syringic acids indicated that these two compounds and their methoxyl groups are unstable under silver oxide and alkali oxidizing conditions.

Studies on the oxidation of aspen lignosulfonate materials were reported recently (*1*). Qualitative and quantitative results were reported for the alkaline cupric oxide and alkaline silver oxide oxidations of ammonia-base fermented aspen spent sulfite liquor and aspen basic calcium lignosulfonate. Arbitrary reactant ratios were employed in these studies, and it was pointed out that operative conditions must have been different in the separate experiments. The arbitrary reactant ratios employed in these earlier studies were determined on a total solids basis from conditions found in the past to give the greatest yields of oxidation products from coniferous liquors (*2, 3*). The poor results obtained when arbitrary reactant ratios determined for coniferous lignosulfonates were applied to aspen lignosulfonate materials led to a study to determine optimum conditions for yields of desirable oxidation products from aspen lignosulfonate materials. The present paper reports continued studies on the cupric oxide and silver oxide oxidations of aspen lignosulfonates in alkaline solution.

The ammonia-base *Torulopsis utilis* commercial spent sulfite liquor of peeled aspenwood (mixed *Populus tremuloides, P. grandidentata,* and *P. tacamahaca*) described in the previous paper (*1*) was employed in the current study. This concentrated liquor contained 31.8 g. solids per 100 g. of liquor, and the solids contained 10.76% methoxyl and 1.8% total sugars.

CUPRIC OXIDE OXIDATIONS

Fourteen experiments were performed on the alkaline cupric oxide oxidation of aspen fermented spent liquor. These included changes in reactant ratios and a few changes in time and temperature of reaction.

General Alkaline Cupric Oxide Oxidation Procedure

All oxidations employed the same general procedure with 314 g. of concentrated fermented aspen spent liquor containing 100 g. of solids, 214 g. of water, and 10.8 g. of methoxyl. For ease of evaluation, both cupric hydroxide and sodium hydroxide quantities were chosen arbitrarily to correspond with simple fractions of their gram molecular weights.

The general procedure will be illustrated by the first experiment. A mixture of 314 g. of concentrated liquor, 293 g. (3.0 moles) of cupric hydroxide, 100 g. (2.5 moles) of sodium hydroxide, and 1286 g. of water (making a total of 1500 g. of water present in the reaction mixture) was stirred and heated in the 1-gal. stainless steel autoclave at 170°C. for 2 hr. After cooling to room temperature, the autoclave was opened, and the mixture was filtered. The reddish cuprous oxide residue was washed thoroughly with hot water. The combined filtrate and washings were measured for volume. An aliquot of this alkaline solution was extracted exhaustively with ether in a continuous extractor, and the ether extract was concentrated to give the so-called "neutral" fraction. The aqueous alkaline solution was acidified with dilute sulfuric acid and again extracted exhaustively with ether. The ether extract was concentrated to give the so-called "acids and phenols" fraction. Solids and methoxyl were run on these fractions. The residual acid aqueous raffinate was neutralized with sodium hydroxide.

Yield data for the ether-soluble fractions and for the methoxyl on these fractions and on the residual neutralized aqueous raffinate are given in Table I. All "acids and phenols" fractions were chromatographed qualitatively on Whatman no. 1 paper and developed in the butanol–2% aqueous ammonia and 10:3:3 butanol-pyridine-water systems at 20°C. Chromatograms were examined by means of ultraviolet light and by spraying with diazotized *p*-nitroaniline (DpNA), 2,4-dinitrophenylhydrazine (2,4-D), and the Mäule reagents. Data for these chromatograms are given in Tables II and III. Compounds identified qualitatively were then determined quantitatively by means of paper chromatographic and spectrophotometric procedures described in detail in earlier papers (*1, 4, 5*). The results of the quantitative studies are given in Table IV.

Discussion of Results on Cupric Oxide Oxidations

Because the nature of the individual experiments

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Table I. Cupric Oxide Oxidations of Concentrated Fermented Aspen Spent Liquor

Expt.	$Cu(OH)_2$, moles	NaOH, moles	Water, ml.[a]	Temp., °C.	Time, hr.[b]	"Neutrals," %[c]	Acids and phenols, %[c]	MeO on acids and phenols, %[d]	MeO on aqueous, %[d]	MeO recovery, %[d]
1	3.0	2.5	1500	170	2	0.18	23.8	42.6	41.4	84.0
2	2.0	2.5	1500	170	2	0.43	25.1	43.2	45.9	89.1
3	4.0	2.5	1500	170	2	0.69	24.2	41.8	27.0	68.8
4	1.5	2.5	1500	170	2	1.10	23.6	37.7	35.0	72.7
5	4.5	2.5	1500	170	2	0.55	23.5	36.7	24.6	61.3
6	2.5	2.5	1500	170	2	0.48	24.4	41.8	30.0	72.8
7	2.0	4.0	1500	170	2	0.70	23.4	34.1	27.0	61.1
8	2.0	1.5	1500	170	2	1.38	20.2	32.3	20.0	52.3
9	2.0	2.5	2500	170	2	0.93	21.9	33.9	27.3	61.2
10	2.0	4.0	2500	170	2	0.45	25.0	38.3	26.8	65.1
11	2.0	2.5	1500	170	5	0.50	16.3	23.9	28.6	52.5
12	2.0	2.5	1500	170	1	0.80	23.1	35.4	24.6	60.0
13	2.0	2.5	1500	160	2	0.65	24.0	35.7	39.2	74.9
14	2.0	2.5	1500	180	2	0.73	20.3	32.1	35.6	68.7

[a] Total water includes that contained in the concentrated liquor.
[b] Time at maximum temperature indicated.
[c] Basis of 100 g. of original starting spent liquor solids.
[d] Basis of 10.8 g. of methoxyl present in original starting spent liquor solids.

evolved somewhat as the studies were in progress, the experiments will be discussed in chronological order.

Experiments 1–6. The first six experiments varied the amount of cupric hydroxide while keeping the sodium hydroxide, water, temperature, and time constant. Amounts of cupric hydroxide varied from 1.5 to 4.5 moles, and the conditions of experiment 2 with 2.0 moles of cupric hydroxide gave the best results, both as to total yields of "acids and phenols" and to methoxyl recovery on the "acids and phenols" and on the total experiment. Although overall yields were higher in experiment 2, the actual yield of vanillin was considerably less than in some of the other experiments. The methoxyl accounted for by the known compounds was also somewhat less than a number of the experiments.

Experiments 7 and 8. In these two experiments the amount of sodium hydroxide was varied from 1.5 to 4.0 moles while the other variables were maintained identical with those of experiment 2. In both experiments, the yield of ether-soluble "acids and phenols" dropped, and the methoxyl recovery also dropped.

Experiment 9. In this experiment the conditions of experiment 2 were maintained except that the amount of water was increased from 1500 to 2500 ml. This gave a sodium hydroxide concentration of 4% instead of the 7% employed in experiment 2. This dilute alkaline reaction mixture also caused a drop in yield of ether-soluble "acids and phenols" and relatively low methoxyl recovery.

Experiment 10. Four moles of sodium hydroxide were employed in this experiment along with 2500 ml. of water. This raised the concentration of sodium hydroxide back to 7%, but reduced the ratio of lignosulfonate and cupric hydroxide. The yield of ether-soluble "acids and phenols" was essentially the same as that of experiment 2, employing 2.5 moles of sodium hydroxide and 1500 ml. of water. The yield of vanillin was also essentially the same, but the methoxyl recovery for the experiment was much lower. This loss in methoxyl was all in the aqueous solution and may have been due to the fact that the volume was so much more in this experiment.

Experiment 11–14. The last four experiments maintained all reactant ratios identical with those of experiment 2 and varied the time and the temperature. These experiments indicated that any increase in either temperature or time lowered the yield of ether-soluble "acids and phenols" while a decrease in either the temperature or time had only a slight effect on the yield.

General Discussion on Cupric Oxide Oxidations

The qualitative chromatographic data of Tables II and III indicated that all conditions employed yielded the same materials except for one compound giving a blue spot with diazotized *p*-nitroaniline with butanol-2% aqueous ammonia R_f 0.81 and 10:3:3 butanol-pyridine-water R_f 0.78. This compound was found

Table II. Cupric Oxide Oxidations

Qualitative paper chromatography of "acids and phenols" fractions[a]

(Butanol saturated with 2% aqueous ammonia)

R_f	DpNA[b]	2,4-D	Mäule	Component
0.00	Brown	+	+	
0.02	Pink	+		
0.05	Tan			
0.08	Blue		+	Syringic acid
0.10	Purple			Vanillic acid
0.12	Pink			*p*-Hydroxybenzoic acid
0.14	Green			*p*-Coumaric acid
0.38	Light green	+	+	Syringaldehyde
0.44	Violet	+		Vanillin
0.50	Yellow	+	+	Acetosyringone
0.60	Violet	+		Acetovanillone
0.81[c]	Blue			
0.88	Violet			

[a] The chromatograms of the "acids and phenols" fractions of all oxidations were the same except as noted.
[b] Colors given are those obtained after spraying with diazotized *p*-nitroaniline followed by saturated sodium carbonate solution.
[c] The spot at R_f 0.81 giving a bright blue spot with diazotized *p*-nitroaniline was found only in oxidations 2, 4, 6, 7, 11, 12 (trace), and 14.

Table III. Cupric Oxide Oxidations

Qualitative paper chromatography of "acids and phenols" fractions[a]

(10:3:3 Butanol-pyridine-water)

R_f	DpNA[b]	2,4-D	Mäule	Component
0.05	Yellow	+		
0.11	Tan			
0.17	Yellow	+		
0.30	Light green	+	+	
0.36	Violet	+		
0.38	Blue		+	Syringic acid
0.44	Purple			Vanillic acid
0.56	Pink			*p*-Hydroxybenzoic and *p*-coumaric acids
0.78	Blue,[c] yellow	+	+	Syringaldehyde, acetosyringone, and other compounds
0.84	Violet	+		Vanillin, acetovanillone, and other compounds

[a] The chromatograms of the "acids and phenols" fractions of all oxidations were the same except as noted.
[b] Colors given are those obtained after spraying with diazotized *p*-nitroaniline followed by saturated sodium carbonate solution.
[c] The spot at R_f 0.78 was blue to diazotized *p*-nitroaniline spray only in oxidations 2, 4, 6, 7, 11, 12 (trace), and 14. Otherwise the spot was only yellow.

Table IV. Cupric Oxide Oxidations of Concentrated Fermented Aspen Spent Liquor Yields of Individual Components[a]

Expt.	Vanillin, %	Syringaldehyde, %	p-Hydroxybenzaldehyde, %	Acetovanillone, %	Acetosyringone, %	Vanillic acid, %	Syringic acid, %	p-Hydroxybenzoic acid, %	p-Coumaric acid, %	MeO in knowns, %
1	10.23	10.78	0.37	1.89	4.31	2.67	4.31	1.89	0.74	48.2
2	9.02	13.01	0.65	1.81	4.52	2.17	5.18	2.19	0.70	53.3
3	12.98	14.17	0.99	2.61	5.46	3.70	6.18	3.42	1.17	66.2
4	12.07	12.98	0.15	2.27	5.26	1.91	3.97	3.35	1.29	59.9
5	12.07	11.54	0.62	1.17	4.73	2.94	5.58	2.43	0.21	61.8
6	10.34	10.93	0.31	2.13	5.16	2.39	3.09	1.70	0.29	50.7
7	10.00	12.06	0.75	2.14	5.15	3.10	4.49	2.16	0.17	64.6
8	9.21	11.98	0.62	1.41	4.84	1.76	2.78	2.28	0.79	52.2
9	10.34	12.35	0.83	2.50	6.58	3.10	4.69	2.72	0.41	65.5
10	9.98	11.01	0.66	1.83	5.14	2.77	4.81	2.50	0.36	59.7
11	13.93	17.21	1.23	3.31	7.52	3.00	3.31	3.07	0.46	84.1
12	12.38	14.29	1.09	2.40	5.84	3.31	5.00	4.22	0.43	72.7
13	8.91	13.00	0.52	2.39	5.62	3.33	5.12	3.85	0.52	67.2
14	11.42	14.82	1.36	2.98	6.68	1.78	2.72	2.96	0.49	65.8

[a] All yields are on the basis of the ether-soluble acids and phenols.

only in the oxidation mixtures that employed small amounts of cupric oxide or large amounts of sodium hydroxide. It was also found in the reactions which employed more drastic conditions such as longer reaction time or higher reaction temperature. The nature of this unknown compound is under investigation. The compound has been concentrated by Craig countercurrent distribution, and studies on its isolation, purification, and identification are in progress.

The quantitative data of Table IV indicate that the yields of individual identified components do not vary a great deal. Thus, the increases and decreases in the yields of ether-soluble "acids and phenols" noted in Table IV must be changes in the yields of compounds as yet unknown. It is interesting to note that experiment 11 which gave the lowest yield of ether-soluble "acids and phenols" actually gave the highest yield of recovered methoxyl in identified compounds.

It should be noted that all experiments in this series of alkaline cupric oxide oxidations yielded a small amount of *p*-coumaric acid as an oxidation product, whereas similar oxidation of this same liquor with alkaline silver oxide gave small amounts of ferulic acid, but no *p*-coumaric acid. (See discussion under silver oxide oxidations.)

SILVER OXIDE OXIDATIONS

Nine experiments were performed on the alkaline silver oxide oxidation of the fermented aspen spent sulfite liquor. Because these experiments were run at atmospheric pressure, and because the silver oxide oxidation reaction has been found in the past to be essentially instantaneous (*2*, *6*), only reactant ratios were studied as variables in the present investigation.

General Alkaline Silver Oxide Oxidation Procedure

All oxidations employed the same general procedure, although differences in reactant ratios required modifications in some instances. All oxidations employed 157 g. of concentrated liquor containing 50 g. of solids and 5.38 g. of methoxyl.

The general procedure will be illustrated by the first experiment. Silver oxide was prepared freshly by mixing aqueous solutions of 170 g. (1 mole) of silver oxide and 40 g. (1 mole) of sodium hydroxide. The mixture was stirred for a short while and filtered. The precipitated silver oxide was washed thoroughly with water and transferred to a 2-liter 3-neck-flask fitted with a silicone-oil sealed stirrer, a reflux condenser, and a thermometer immersed below the level of the reaction mixture. The silver oxide was covered with 500 ml. of water and treated with stirring with 120 g. (3 moles) of sodium hydroxide pellets. The temperature increase at this point was dependent upon the amount of sodium hydroxide added under constant stirring conditions. In order to maintain starting temperature conditions uniform throughout the series of experiments, a starting temperature of 65°C. was selected arbitrarily. If the addition of the sodium hydroxide raised the temperature above 65°C., the mixture was allowed to cool to 65°C. before the spent liquor was added. On the other hand, if the temperature did not reach 65°C. after sodium hydroxide addition, heat was applied to raise the temperature of the mixture to 65°C. With the temperature at 65°C., the spent liquor was added at one time. The reaction was instantaneous, raising the temperature to 89°C., and the black silver oxide was reduced to metallic silver. The mixture was then heated to boiling under reflux with stirring for 4 hr., and allowed to cool.

The alkaline mixture was filtered, and the silver residue was washed thoroughly with water. The combined alkaline filtrate and washings were extracted continuously with ether, and the ether extract was concentrated to a small volume for analysis. This extract contained the "neutral" materials. The alkaline aqueous raffinate was acidified with dilute sulfuric acid and again extracted continuously with ether. The ether extract was concentrated to yield the ether-soluble "acids and phenols." The residual acid aqueous raffinate was neutralized with sodium hydroxide solution. Yield data for the ether-soluble fractions and for the methoxyl on these fractions and on the neutralized aqueous residue are given in Table V. All ether-soluble "acids and phenols" fractions were analyzed qualitatively by means of paper chromatography and quantitatively by means of paper chromatography and spectrophotometry as noted earlier for the cupric oxide oxidation study. The results of the quantitative studies are given in Table VI.

In addition to the compounds noted in Table VI a number of other compounds were found, but were not identified. All ether-soluble "acids and phenols" fractions gave essentially the same qualitative chromatograms, but the spots obtained varied in intensity in the various experiments. In addition to the identified compounds of Table VI, compounds with the following R_f's in butanol–2% aqueous ammonia were

Table V. Silver Oxide Oxidations of Concentrated Fermented Aspen Spent Liquor

Expt.	Ag_2O, moles	NaOH, moles	"Neutrals," %[a]	"Acids and phenols," %[a]	MeO on "acids and phenols," %[b]	MeO on aqueous, %[b]	MeO recovery, %[b]
1	0.50	3.0	0.1	11.5	7.7	57.4	65.1
2	0.75	3.0	0.18	15.3	13.8	41.6	55.4
3	0.25	3.0	0.22	10.1	8.0	40.9	48.9
4	1.0	3.0	0.28	8.2	10.2	42.9	53.1
5	0.5	2.0	0.22	8.7	9.1	30.1	39.2
6	0.88	3.0[c]	0.20	9.2	5.8	47.4	53.2
7	0.63	3.0	0.10	17.0	16.2	46.3	62.5
8	1.0	3.0[c]	0.16	10.9	8.4	49.1	57.5
9	0.58	3.0	0.20	16.2	10.8	25.5	36.3

[a] Basis of 50 g. of original total solids.
[b] Basis of 5.38 g. of original methoxyl present in total solids.
[c] This experiment employed twice as much water.

noted: 0.00, 0.04, 0.17, 0.19, 0.21, and 0.84. These compounds gave spots with the bis-diazotized benzidine or diazotized *p*-nitroaniline reagents, but not with the other sprays employed, indicating that they are phenolic in character, but do not possess carbonyl or syringyl activity.

Discussion of Results on Silver Oxide Oxidations

Again, because the nature of the individual experiments evolved as the studies were in progress, the individual experiments will be discussed in chronological order.

Experiments 1, 2, and 3. The yields of experiment 1 with one-half mole of silver oxide were not very indicative so experiment 2 was performed in the same manner with 50% more silver oxide or three-fourths mole. During the reaction the temperature rose to 95°C. after addition of the concentrated liquor. The yields of aldehydes decreased, and the yields of acids increased. In experiment 3, the silver oxide was reduced to one-fourth mole. Under these reactant ratios, the reaction which occurred after liquor addition was very slow, gradually raising the temperature to 75°C. The yields of acids dropped in this experiment, but the yields of vanillin and syringaldehyde increased. In addition, *p*-hydroxybenzaldehyde was found under these conditions which resulted in higher aldehyde yields. This reactant ratio was the only one of those tried that yielded any *p*-hydroxybenzaldehyde. In all three of these oxidations, the silver oxide was completely reduced to metallic silver. These first three oxidations indicated that higher yields of acids would be obtained with higher silver oxide ratios.

Experiment 4. One mole of silver oxide was employed in this experiment. Unexpectedly, the reaction taking place after liquor addition was very slow, but the temperature gradually rose to the boiling point of 102°C. Even at this temperature the mixture was very thick and appeared to contain a mass of mixed organic and inorganic material. Stirring was very difficult. A silver mirror deposited on the flask. After a few minutes at the boiling temperature, the mixture suddenly lost its viscous properties, the silver precipitate became granular, and stirring became rapid. This oxidation gave the lowest yield of ether-soluble "acids and phenols" of any of the nine oxidation experiments, but the vanillic acid and syringic acid percentages in these ether-soluble "acids and phenols" were much higher than in any other experiment. In addition, the methoxyl recovered in the known materials was the highest of any of the experiments. The yields of aldehydes were very low.

Experiment 5. The fifth experiment employed the same silver oxide as did experiment 1, but in this case only 2 moles of sodium hydroxide were used. The addition of the concentrated liquor raised the temperature to 91°C., and the reaction proceeded smoothly. However, the data of Tables V and VI indicate that the overall yield of ether-soluble "acids and phenols" was very low, and the percentage of identified compounds in this fraction was also very low.

Experiment 6. In this experiment, 0.88 mole of silver oxide was employed, but in this case the amount of water was doubled. Under these conditions, the concentration of the resulting sodium hydroxide was only one half of that employed in other experiments using 3 moles of sodium hydroxide. In this experiment, the reaction following the addition of the concentrated liquor was very slow and raised the temperature of the reaction mixture very gradually until it reached 83°C. The yields obtained were uniformly low.

Experiment 7. Experiment 7 employed 0.63 mole of silver oxide. The reaction which took place after addition of the concentrated liquor was vigorous and raised the temperature to 93°C. In this experiment, foaming took place at this point, and a little water was added to retard the foaming. The yield of ether-soluble "acids and phenols" in this experiment was

Table VI. Silver Oxide Oxidations of Concentrated Fermented Aspen Spent Liquor

Yields of individual components[a]

Expt.	Vanillin, %	Syringaldehyde, %	*p*-Hydroxybenzaldehyde, %	Acetovanillone, %	Acetosyringone, %	Vanillic acid, %	Syringic acid, %	Ferulic acid, %	*p*-Hydroxybenzoic acid, %	MeO in knowns, %
1	1.5	0.3	0.0	0.7	1.6	5.5	5.8	1.3	5.5	55.6
2	0.6	0.5	0.0	0.8	1.4	7.6	4.8	0.9	5.9	40.4
3	5.3	2.4	0.6	0.6	0.9	2.9	4.1	0.7	7.5	48.1
4	0.4	0.5	0.0	1.8	1.9	22.7	18.8	3.8	13.7	85.6
5	0.4	1.0	0.0	2.2	1.9	5.1	4.2	1.6	10.0	35.2
6	0.2	0.2	0.0	0.8	0.3	6.0	5.1	1.5	7.2	48.2
7	0.8	0.7	0.0	1.0	2.4	8.6	6.0	2.5	4.8	51.1
8	0.1	0.7	0.0	1.3	1.0	9.2	5.6	1.0	7.5	53.1
9	1.7	0.4	0.0	1.0	3.3	6.9	6.1	1.2	5.2	70.5

[a] All yields are on the basis of the ether-soluble "acids and phenols."

higher than in any other experiment in this series. In addition, the methoxyl content of these acids and phenols was also highest.

Experiment 8. This experiment was made with the same silver oxide and sodium hydroxide ratios as experiment 4, but with twice as much water. Again, as in experiment 6 with more water, the reaction taking place after liquor addition was very slow, and the temperature rose gradually to 84°C. The yield of ether-soluble "acids and phenols" was higher than in experiment 4, but the methoxyl recovery in these materials was lower.

Experiment 9. The ninth and last oxidation employed 0.58 mole of silver oxide. The reaction after liquor addition was vigorous, and the temperature rose to 89°C. The recovery of ether-soluble "acids and phenols" and of methoxyl in these materials was good, but not as good as in experiment 7.

General Discussion on Silver Oxide Oxidations

Every experiment on the silver oxide oxidation of aspen fermented spent liquor yielded a small amount of ferulic acid and no *p*-coumaric acid whatsoever, whereas it was noted in the cupric oxide study that *p*-coumaric acid was found in every oxidation, and no ferulic acid could be found in any of them. The cause for the instability of *p*-coumaric acid in the silver oxide oxidation reaction is unknown, but the absence of *p*-coumaric acid and the related *p*-hydroxybenzaldehyde (except in the case of experiment 3) in the silver oxide oxidation mixtures were accompanied by higher yields of *p*-hydroxybenzoic acid. This indicates that, under the silver oxide oxidation conditions, moieties in the lignosulfonate which give *p*-coumaric acid and *p*-hydroxybenzaldehyde under cupric oxide oxidation conditions, are converted directly to *p*-hydroxybenzoic acid under the conditions of the silver oxide oxidations. Apparently, this oxidation of the aldehyde to the acid is more complete in the case of *p*-hydroxybenzaldehyde than it is in the cases of vanillin and syringaldehyde.

It is also apparent that moieties in the lignosulfonate which gave ferulic acid under silver oxide oxidation conditions, gave vanillin under conditions of the cupric oxide oxidations.

An attempt was made to evaluate the results of the silver oxide oxidation experiments as results were obtained. About the only definite conclusion reached was that a large loss of methoxyl took place in all oxidations with silver oxide and alkali. Several trends in reactions were noted. High silver oxide ratios yielded lower aldehydes and higher acids, and low silver oxide ratios yielded higher aldehydes and lower acids. Highest yields of ether-soluble "acids and phenols" were obtained at 0.63 mole of silver oxide, and this silver oxide ratio also gave the highest yield of methoxyl recovery in this ether extract. There appeared to be no relationship between the yield of ether-soluble "acids and phenols," the methoxyl contained in these materials, the loss in methoxyl, and the amount of silver oxide employed. The loss of methoxyl in all experiments ranged from 35 to 64%.

This loss in methoxyl led to experiments on the silver oxide oxidation of known compounds. Inasmuch as vanillic and syringic acids are the two chief products of aspen lignosulfonate oxidation, and vanillic acid is the chief product of coniferous lignosulfonate oxidation, these two acids were chosen as starting materials for these experiments. Experimental conditions were chosen to correspond with the conditions of experiment 7 which gave the best overall yield of ether-soluble materials with the greatest methoxyl recovery.

Table VII. Silver Oxide Oxidations of Vanillic and Syringic Acids

	Vanillic acid	*Syringic acid*
Silver oxide, moles	0.63	0.63
Sodium hydroxide, moles	3.0	3.0
Ether-sol. "acids and phenols," %[a]	72.1	22.1
Methoxyl on "acids and phenols," %[b]	56.1	13.2
Methoxyl on aqueous residue, %[b]	10.8	31.2
Methoxyl recovery, %[b]	65.9	44.4
Vanillic acid, %[c]	34.6	
Syringic acid, %[c]		6.6
Methoxyl in knowns, %[c]	44.5	11.2

[a] Basis of weight of starting compound.
[b] Basis of weight of 5.35 g. of starting methoxyl.
[c] Basis of weight of ether-soluble "acids and phenols."

Silver Oxide Oxidation of Vanillic Acid and Syringic Acid

Freshly prepared silver oxide was prepared from 1.25 moles of silver nitrate and 1.25 moles of sodium hydroxide. The washed silver oxide was covered with only 400 ml. of water in the reaction flask and treated with 100 g. of sodium hydroxide (2.5 moles). When the temperature was 65°C., a solution of 29 g. (0.17 mole containing 5.35 g. of methoxyl) of vanillic acid and 20 g. (0.5 mole) of sodium hydroxide in 100 ml. of water was added. The addition of this mixture produced no temperature rise and no apparent reaction. The mixture was heated to boiling with stirring under reflux for 4 hr. As the mixture approached the boiling point, the silver oxide became reduced with the separation of metallic silver. After 4 hr., the mixture was cooled somewhat, filtered through sintered glass, and the precipitated silver was washed thorougly with water. The combined filtrate and washings were acidified with dilute sulfuric acid and processed as in the preceding nine experiments. Yield data are given in Table VII.

Syringic acid was oxidized under conditions identical with those described for vanillic acid except that only 17 g. of syringic acid (containing 5.35 g. of methoxyl) was employed. Data for the syringic acid oxidation are also given in Table VII.

The data of Table VII are enlightening. They indicate that both of these principal oxidation products of lignosulfonates are unstable in the presence of excess silver oxide and alkali. The methoxyl loss in the ether-solubles in the case of vanillic acid was only 44% of the starting methoxyl, but only 25% of the starting vanillic acid was recovered. Thus, much of the methoxyl recovered in the ether-soluble "acids and phenols" was due to unidentified reaction products. In the case of syringic acid, only 1.5% of the original material was recovered, and even the methoxyl recovered in the "acids and phenols" fraction was very low. Apparently, the methoxyls on the syringic nucleus are more susceptible to removal by silver oxide and alkali than are those on the guaiacyl nucleus. It is possible that the ring system with three oxygen substitutions on the ring is more susceptible to oxidation and more complete rupture of the aromatic ring.

Qualitative Paper Chromatography of Model Compound Silver Oxide Oxidations

The silver oxide oxidation mixtures obtained from vanillic and syringic acids were chromatographed qualitatively on paper, and the spots were located by means of diazotized *p*-nitroaniline, 2,4-dinitrophenylhydrazine, ferric chloride, and Mäule spray reagents. Definite spots were located in the vanillic acid chromatograms with diazotized *p*-nitroaniline at butanol–2% aqueous ammonia R_f's 0.00, 0.02 (violet with ferric chloride), 0.05, 0.12, and 0.32. None of these spots gave positive tests with 2,4-dinitrophenylhydrazine indicating that no carbonyl compounds were formed in this experiment. The syringic acid oxidation gave spots with diazotized *p*-nitroaniline at butanol–2% aqueous ammonia R_f's 0.00, 0.02, and 0.08. These spots were also all positive to the Mäule reagents, indicating syringyl activity. None of these spots have been identified.

The results of these two experiments on model compounds led to an abandonment of further experiments on the silver oxide oxidation of hardwood lignosulfonate materials.

SUMMARY

Quantitative studies were made on the alkaline cupric oxide and alkaline silver oxide oxidations of fermented aspen spent sulfite liquor under varying conditions of time, temperature, and reactant ratios. Overall yields of ether-soluble "acids and phenols" were determined, and the yields of individual oxidation products were reported along with methoxyl data for all fractions and isolated materials. Model compound studies were included to help explain some of the results obtained.

LITERATURE CITED

1. Pearl, I. A. and Beyer, D. L., *Tappi* 42: 800 (1959).
2. Pearl, I. A. and Beyer, D. L., *Tappi* 33: 508 (1950).
3. Pearl, I. A. and Beyer, D. L., *Tappi* 33: 544 (1950).
4. Pearl, I. A., Beyer, D. L., Johnson, B., and Wilkinson, S., *Tappi* 40: 374 (1957).
5. Pearl, I. A., Beyer, D. L., and Johnson, B., *Tappi* 41: 255 (1958).
6. Pearl, I. A., *J. Am. Chem. Soc.* 71: 2196 (1949).

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The Mechanism of Acid Bisulfite Pulping

I. The Effects of Temperature Schedule and Chip Size on Pulping Rate

W. J. NOLAN

Mill-size and shredded spruce chips were cooked in solutions of ammonium bisulfite and sulfurous acid (5.2% total SO_2, 1.2% combined SO_2), using three different temperature schedules: 9 hr. to a max. of 135°C.; 6 hr. to a max. of 142°C.; 30 min. to a max. of 148°C. Total and screened yield curves and pulp analysis, including lignin content and D.P. of cellulose, are presented. The results showed that no burning occurred, even when the cooks were brought to 148°C. within 3 min. of the time chips and liquor were mixed. In all cases, shredded chips cooked more rapidly and to higher screened yields than mill-size chips. With shredded chips and 30 min. to max. temp., a screened yield of 50.6% was obtained in a total cooking time of 120 min. The pulp contained 8.2% lignin and the cellulose had a D.P. of 1900. Mill-size chips could not be cooked satisfactorily at the rapid temperature schedule, maximum screened yields being less than 45%. Additional cooks were carried out, in which both mill-size and shredded chips were pre-impregnated with cooking liquor by submerged soaking for 6 hr. at room temperature. A temperature schedule of 30 min. to 148°C. was used. It was found that the pre-impregnation caused a definite decrease in the reaction rate, decreased screened yield and increased cellulose degradation. Pre-impregnation of the shredded chips with ammonium bisulfite containing no free SO_2 had no effect on either reaction rate or screened yield, but caused a slight increase in cellulose degradation.

Ever since acid bisulfite pulping was first practiced, almost 100 years ago, it has been generally accepted as fact that the bisulfite solution must have completely penetrated the wood chips before the delignification reactions can be started. As expressed by Ericsson, McCarthy and Pearson (*1*), wood chips and acid bisulfite cooking liquor are brought very slowly (over a period of 2 to 4 hr.), to a temperature of 110°C. in order that complete penetration of the bisulfite occurs before any of the chips reach a temperature in excess of this 110°C. Otherwise, a condensation of lignin, or "burning," occurs because of excess acidity when the sulfonation reaction begins.

It now becomes increasingly important, as commercial pulping moves more and more toward continuous methods, to determine whether this theory of penetration followed by delignification is a true picture of the pulping mechanism. If so, continuous pulping operations will require a prepenetration of cooking liquor into the chips before the mixture reaches the constant temperature zone of the digester.

If this penetration theory is not the correct explanation of the mechanism of acid bisulfite pulping, is it possible that the same mechanism applies here as has been found recently to be true for sulfate, or kraft, pulping? That is, that the cooking chemicals begin reacting with the lignin on the chip surface as soon as the temperature is high enough for an appreciable reaction rate. Thereafter, the reaction chemicals eat their way toward the center of the chip, eliminating the

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need for a penetration of liquor into the chip before the reaction starts. Under such circumstances the physical dimension of the wood chip becomes of paramount importance, and should be adjusted so that the shortest possible path from chip surface to center is presented.

It was this line of reasoning which led the University of Florida into a research program aimed at a better understanding of the pulping variables and the part they play in the overall mechanism of acid bisulfite pulping. As a first step in this program it was necessary to prove whether or not the old penetration theory really applies to the process. If it does apply, then the physical dimensions of the chip, other than length in the grain direction, are not important, since fluid flow in the chip is predominantly in the grain direction. Further, if the time interval for bringing the digester contents from room temperature to maximum temperature is made progressively short, a point will be reached where liquor penetration cannot occur before the reaction starts. Under such circumstances, the wood cannot be pulped but will burn, if the penetration theory applies to the process.

The following presentation describes the experiments undertaken to explore the two variables: chip dimensions across the grain, and time to maximum cooking temperature. Batch methods are used throughout, wherein chips and liquor are mixed in a cold digester and a finite time is used to bring the digester contents to cooking temperature.

EXPERIMENTAL PROCEDURE AND RESULTS

The wood used throughout the experiments, white spruce, was obtained from the mill of Hudson Pulp and Paper Corp., Augusta, Me. The logs were chipped in the 10-knife chipper at Hudson's Palatka, Fla., mill with the chipper knives set to produce chips $^5/_8$ in. long in the grain direction. Half of the chips were carefully screened, discarding the fraction which passed through 4-mesh screen and the fraction which was retained on a 1 by 2-in. screen. The accepted chips, designated as mill-size chips, were air-dried and stored for future use.

The second half of the original moist chips were shredded in the 100-hp. Vertiflex refiner supplied by E. D. Jones Corp., Pittsfield, Mass. Clearance of the toothed plates was 0.850 in. The shredded chips were then screened on a Link-Belt vibrating screen, the accepted fraction being that material which passed, end-wise, through a 3-mesh screen and was retained on an 8-mesh screen. These shredded chips were also air-dried and stored.

Samples of the spruce chips were ground and analyzed by TAPPI Standard methods. The average analysis, based on ovendry chips, was as follows:

Alcohol-benzene soluble	1.3
Hot-water soluble	2.3
1% NaOH soluble	10.3
Lignin	26.9

The cooking liquor used throughout the tests consisted of ammonium bisulfite and sulfurous acid made up, as nearly as possible, to uniform concentration of free and combined SO_2. The values decided upon were 5.2% total SO_2 and 1.2% combined SO_2. Ammonia base was used because of its less drastic corrosive action. Total and free SO_2 were titrated by the Palmrose method (*2*) because it gave somewhat better results than TAPPI Standard T 604 m 45 for the ammonia-base liquors. As a check on the analytical results, ammonia determinations were also made on the liquor, using an ammonia evolution method developed at the laboratory. This procedure made possible the direct measurement of combined SO_2.

The pulping experiments were carried out in the six-digester unit previously described (*2*). Instead of using a blowpit, pulps were blown through a cyclone directly into a canvas trough before transferring to cloth bags for washing. In order to carry out sulfite pulping it was necessary to rebuild the digester installation, replacing all threaded joints with welded fittings. Also, the quick-opening blow valves and all other gate valves were replaced with Teflon-lined, Type F Durco plug valves supplied by the Duriron Co., Dayton, Ohio. These modifications insured that no SO_2 could be lost through leakage during the cooks.

A typical series of cooks, to evaluate one cooking curve, consisted of the following procedure. Airdry chips, either mill-size or shredded, were weighed in sufficient quantity to supply 1000 g. of ovendry wood per digester charge. Each wood charge was water-soaked by submergence in water at room temperature for 6 hr. The soaked chips were then drained, weighed and stored in closed containers overnight. At this point, the chips were 35 to 45% ovendry wood.

Either five or six digesters were charged with these carefully weighed, water-soaked chips. Seven liters of cold cooking liquor were then added to each digester. Digester valves were closed and steam was applied to the steam chest at such a rate that maximum steam pressure would be reached in the prescribed length of time. All valves were kept closed until the digester was blown, no relief of any kind being employed. Digesters were blown periodically, beginning either at the time maximum temperature was reached or slightly before. Whenever cooking conditions were changed drastically, a set of pilot cooks was carried out to set up the range of cooking times so that the first cook blown would be in the range of 60 to 80% yield, with the last cook continued to a yield of less than 50%.

Immediately before blowing a cook, the pressure in the digester was measured. After blowing, each cook was washed for about 3 to 4 hr. in canvas bags, using water at 170°F. The pulps were then screened on the Valley laboratory screen, equipped with an 8-cut screen. There was no mechanical action on the pulp from the moment of blowing up to the screening operation. The screened pulp was collected in canvas bags, pressed to about 25% ovendry, broken into small pieces, weighed and stored in an airtight container. Moisture content was evaluated after 24-hr. storage. The screenings were ovendried, weighed and ground to 20 mesh for chemical analysis.

No attempts were made to analyze the waste liquor from the cooks. There were no physical tests made on any of the pulp, the degree of polymerization of cellulose being the only criterion of pulp quality. The D.P. was determined from viscosity data, using the Hercules* Conversion Chart for Cellulose Viscosities, Form 803, ZM 11-48. Viscosities of pulps were deter-

* Hercules Powder Co., Wilmington, Del.

mined by TAPPI Standard Method T 230 sm-50, using 0.5 molal cupriethylenediamine and Ostwald-Fenske pipets. In all cases, pulps were completely delignified before viscosity determination, employing a treatment with sodium chlorite and acetic acid.

Lignin contents of pulps and screenings were determined with 72% H_2SO_4, using TAPPI Standard T 222 m-54. No previous extraction with alcohol-benzene had been carried out before the lignin analyses. Therefore, the lignin percentages reported may be slightly high owing to small amounts of acid-insoluble resins. In the case of lignin content of the original spruce wood, lignin was determined according to TAPPI Standard T 13 m-54, on material which had been previously extracted with alcohol-benzene.

Table I. Batch Pulping of Spruce by the Ammonium Acid Bisulfite Process

Cook no.	Cooking time, min. To max. temp.	Cooking time, min. At max. temp.	Max. temp., °C	Max. total pressure, p.s.i.g.	SO_2 in cooking liquor, % Total	SO_2 in cooking liquor, % Comb.	Yield, % of O.D. wood Total	Yield, % of O.D. wood Screened	Screenings, % of total yield	Lignin, % in Pulp	Lignin, % in Screenings	D.P. of pulp (lignin free)
Mill-size chips; no pre-impregnation												
3084	30	0	148	...	5.2	1.2	87.5	0	100	...	28.0	...
3085	30	45	148	88	5.2	1.2	67.8	0	100	...	24.0	...
3086	30	90	148	90	5.2	1.2	58.6	30.4	48.1	10.0	20.5	1957
3087	30	135	148	94	5.2	1.2	52.4	39.4	24.8	5.7	22.0	1850
3088	30	180	148	96	5.2	1.2	48.9	42.0	14.0	2.9	22.4	1659
3089	30	0	148	...	5.3	1.2	87.9	0	100	...	28.3	...
3090	30	45	148	89	5.3	1.2	69.6	0	100	...	23.7	...
3091	30	90	148	94	5.3	1.2	58.8	33.0	43.9	9.9	22.1	1801
3092	30	135	148	98	5.3	1.2	51.7	38.9	24.8	4.9	20.9	1747
3093	30	180	148	100	5.3	1.2	48.5	41.5	14.4	3.2	24.1	1595
3145	360	−30	142	74	5.1	1.2	72.2	0	100	...	21.8	
3146	360	+15	142	82	5.1	1.2	64.6	18.2	71.8	11.0	18.7	
3147	360	60	142	85	5.1	1.2	58.3	32.0	45.1	6.9	18.5	
3148	360	90	142	86	5.1	1.2	55.9	38.2	31.7	5.2	18.0	2078
3149	360	135	142	86	5.1	1.2	52.3	40.8	21.9	4.3	16.8	1964
3150	360	180	142	89	5.1	1.2	49.8	44.1	11.5	3.1	15.6	1862
3151	360	−30	142	76	5.2	1.2	72.0	0	100	...	22.1	
3152	360	+15	142	84	5.2	1.2	65.0	17.7	72.8	10.1	19.4	
3153	360	60	142	84	5.2	1.2	57.6	31.8	44.8	5.9	18.9	
3154	360	90	142	85	5.2	1.2	56.0	35.7	36.2	5.7	18.3	2043
3155	360	135	142	87	5.2	1.2	52.5	41.9	20.2	4.3	16.5	1979
3156	360	180	142	88	5.2	1.2	50.7	44.8	11.7	2.9	16.6	1874
3124	540	0	135	68	5.2	1.2	60.9	30.9	49.3	10.6	19.8	
3125	540	120	135	69	5.2	1.2	52.9	44.8	15.4	5.2	19.5	
3126	540	210	135	70	5.2	1.2	49.3	47.0	4.7	3.0	17.0	1505
3127	540	300	135	70	5.2	1.2	45.5	44.4	2.4	1.9	17.9	1360
3128	540	360	135	69	5.2	1.2	45.2	44.7	1.2	2.2	22.3	1213
3129	540	0	135	68	5.3	1.2	61.7	29.8	51.7	12.1	19.8	
3130	540	120	135	69	5.3	1.2	52.3	43.8	16.3	6.3	18.9	
3131	540	210	135	70	5.3	1.2	48.1	46.1	4.1	4.0	17.6	1541
3132	540	300	135	70	5.3	1.2	46.3	45.2	2.4	1.8	18.5	1368
3133	540	360	135	...	5.3	1.2	44.6	44.0	1.4	2.3	19.8	1227
Mill-size chips; pre-impregnated by 6 hr. submergence of dry chips in cooking liquor (5.3% total, 1.2% combined SO_2)												
3241	30	15	148	96	5.4	1.2	76.2	...	100	...		
3242	30	60	148	99	5.4	1.2	66.9	3.6	94.7	13.2		
3243	30	105	148	101	5.4	1.2	60.3	16.3	73.0	8.8		
3244	30	150	148	103	5.4	1.2	55.0	23.5	57.2	5.6		1687
3245	30	195	148	98	5.4	1.2	52.3	25.2	51.9	3.1		1461
3246	30	240	148	90	5.4	1.2	47.7	27.1	43.1	2.1		1096
Shredded chips; unimpregnated												
3074	30	0	148	...	5.2	1.2	88.7	...	100	...	28.4	
3075	30	30	148	84	5.2	1.2	73.4	...	100	...	25.4	
3076	30	60	148	87	5.2	1.2	64.6	7.3	88.8	18.0	20.1	1609
3077	30	90	148	90	5.2	1.2	57.0	16.1	19.1	12.7	17.4	1998
3078	30	120	148	92	5.2	1.2	52.4	50.6	3.5	8.2	...	1899
3079	30	0	148	...	5.2	1.2	87.6	...	100	...	29.2	
3080	30	30	148	84	5.2	1.2	72.3	...	100	...	25.5	
3081	30	60	148	86	5.2	1.2	63.9	8.1	87.3	18.0	20.0	1602
3082	30	90	148	89	5.2	1.2	56.4	46.5	17.6	10.9	17.1	2015
3083	30	140	148	91	5.2	1.2	49.2	48.6	1.2	5.1	30.0	1837
3139	360	−30	142	72	5.1	1.2	69.3	...	100	...	19.1	
3140	360	0	142	80	5.1	1.2	63.5	14.3	77.5		15.8	
3141	360	30	142	81	5.1	1.2	57.9	44.3	23.5	9.3	13.2	
3142	360	60	142	84	5.1	1.2	53.1	51.8	2.5	5.6	14.3	2004
3143	360	90	142	84	5.1	1.2	51.5	51.1	0.7	4.0	...	1971
3144	360	120	142	100	5.1	1.2	49.7	49.6	0.2	2.5	...	1944
3157	360	−30	142	74	5.3	1.1	67.2	...	100	...	19.4	
3158	360	0	142	83	5.3	1.1	60.4	27.2	55.0	13.0	14.9	
3159	360	30	142	83	5.3	1.1	56.3	50.1	11.1	9.7	19.4	
3160	360	60	142	84	5.3	1.1	52.3	51.0	2.5	6.6	16.2	2018
3161	360	90	142	85	5.3	1.1	50.6	50.3	0.6	3.4	...	1937
3162	360	120	142	86	5.3	1.1	48.8	48.7	0.2	1.7	...	1852
3119	540	0	135	64	5.2	1.2	58.3	36.7	37.0	11.7	16.1	
3120	540	30	135	65	5.2	1.2	55.3	46.7	15.7	9.7	15.2	
3121	540	75	135	66	5.2	1.2	52.3	48.9	6.6	6.6	16.7	1737
3122	540	135	135	68	5.2	1.2	49.8	49.1	1.3	3.8	16.7	1698
3123	540	195	135	66	5.2	1.2	48.0	47.7	0.5	3.0	...	1483
3134	540	0	135	66	5.2	1.2	56.8	41.8	26.3	10.6	17.0	
3135	540	30	135	68	5.2	1.2	54.6	49.4	9.6	8.6	17.3	
3136	540	75	138	68	5.2	1.2	51.3	49.7	3.1	6.2	19.6	1692
3137	540	135	135	70	5.2	1.2	48.9	48.5	0.7	3.1	...	1584
3138	540	195	135	70	5.2	1.2	46.8	46.7	0.2	1.8	...	1345
Shredded chips; pre-impregnated by 6 hr. submergence of dry chips in cooking liquor (5.4% total, 1.2% combined SO_2)												
3235	30	0	148	89	5.4	1.2	89.3	...	100	...		
3236	30	30	148	96	5.4	1.2	74.0	...	100	...		
3237	30	60	148	99	5.4	1.2	67.1	3.5	9.48	16.4		
3238	30	90	148	100	5.4	1.2	60.6	20.3	66.5	14.7		1749
3239	30	120	148	102	5.4	1.2	55.0	39.6	27.9	10.7		1718
3240	30	150	148	103	5.4	1.2	51.9	47.1	9.3	8.1		1685
Shredded chips, pre-impregnated by 10 min. boiling and cooling in bisulfite liquor (2.9% total, 1.5% combined SO_2)												
3247	30	0	148	82	5.3	1.2	85.6	...	100	...		
3248	30	30	148	88	5.3	1.2	71.4	...	100	...		
3249	30	60	148	90	5.3	1.2	62.6	11.8	81.1	14.3		
3250	30	90	148	90	5.3	1.2	55.1	46.0	16.6	11.0		1750
3251	30	120	148	93	5.3	1.2	50.2	49.7	0.9	6.0		1680
3252	30	150	148	95	5.3	1.2	43.6	43.3	0.6	3.6		1566

7.0 liters of liquor per 1000 g. wood were used in all cases except for those requiring 240 min. to max. temp., when 5.0 liters were used.

Table II. Lignin and Carbohydrate Content of Pulps

Max. temp., °C	Total cooking time, min.	Total yield, % of O.D. wood			Screened yield, % of O.D. wood	
		Pulp	Lignin	Carbohydrate	Pulp	Carbohydrates
Mill-size Chips						
148	30	87.7	24.7	63.0	0	
148	75	68.7	16.4	52.4	0	
148	120	58.7	9.0	49.8	31.7	28.6
148	165	52.0	4.8	47.2	39.2	37.1
148	210	48.7	3.0	45.8	41.8	40.5
142	330	72.1	15.8	56.3	0	0
142	375	64.8	10.8	53.4	18.0	16.0
142	420	58.0	6.4	51.5	31.9	29.8
142	450	56.0	5.5	50.5	37.0	35.0
142	495	52.4	3.6	48.8	41.4	39.6
142	540	50.2	2.3	48.0	44.4	43.1
135	540	63.3	9.6	51.8	30.4	26.9
135	660	52.6	4.1	48.0	44.3	41.8
135	750	48.7	1.9	46.8	46.6	45.0
135	840	45.9	1.0	44.9	44.7	44.0
135	900	44.9	1.1	43.8	44.4	43.4
Shredded Chips						
148	30	88.2	25.4	62.8	0	0
148	60	72.8	18.5	54.4	0	0
148	90	64.2	12.7	51.6	7.7	6.3
148	120	56.7	7.2	49.4	46.3	38.4
148	150	52.4	4.5	47.9	50.6	45.9
148	170	49.2	2.6	46.6	48.6	46.1
142	330	68.2	13.1	55.2	0	0
142	360	62.0	9.1	52.8	20.8	18.0
142	390	57.1	6.0	51.1	47.2	42.8
142	420	52.7	3.3	49.4	51.4	48.2
142	450	51.0	1.9	49.1	50.7	48.8
142	480	49.2	1.0	48.2	49.2	48.2
135	540	57.6	7.4	50.2	39.2	34.9
135	570	55.0	5.5	49.4	48.0	43.7
135	615	51.8	3.6	48.2	49.3	46.2
135	675	49.4	1.8	47.6	48.8	46.8
135	735	47.4	1.2	46.2	47.2	46.1

A few pulps were analyzed for pentosan content using TAPPI Standard T 223 m-58.

In the experimental cooks, three different temperature-rise periods were used. Preliminary cooks showed that, as temperature-rise periods became increasingly long, the maximum temperature of the cooks had to be reduced. It had been originally planned to cook at 148°C. (50 p.s.i.g. steam pressure). It was found that, with a temperature-rise period of 6 hr. to reach 148°C., shredded wood had cooked completely to pulp by the time maximum temperature was reached. Therefore, the maximum temperature was reduced in this case to 142°C. (40 p.s.i.g. steam pressure). Similarly, it was found that, for a temperature-rise period of 9 hr., the maximum temperature should not exceed 135°C. (30 p.s.i.g. steam pressure), if normal cooking curves were to result. In addition, for these particularly long cooks it was necessary to reduce the liquor charge from the planned value of 7 liters per 1000 g. of ovendry wood to a value of 5 liters. From these preliminary cooks the complete program of cooking was worked out as follows, for both mill-size and shredded chips.

Max. temp., °C.	148	142	135
Time to max. temp., min.	30	360	540
Time at max. temp.	as needed, depending on pulping rate		
Liquor-wood ratio (lb. liquor per lb. O.D. wood)	7.0	7.0	5.0

After this program of experimentation had been completed, a study of the effects of pre-impregnation of the chips with cooking liquor was undertaken. Some thought was given to the best method for impregnating the acid bisulfite liquor into the chips. It was obvious that the method of boiling and cooling the chips submerged in cooking liquor, as used in this laboratory for kraft liquor impregnation (*4*), would be inappropriate because of the high volatility of sulfur dioxide. A modification of the evacuation method of Jayme and Lockmuller-Kerler (*5*) was tried. Airdry chips were charged into a stainless steel pressure vessel. The chips were held off the bottom of the container by a perforated tray to permit easy contact with liquor. The vessel was evacuated to 5-mm. Hg absolute. This vacuum was held on the chips for 30 min. At the end of this time, a connecting valve to a carboy of cooking liquor was opened and liquor was drained into the vessel, covering the chips. Chips remained in contact with the liquor for 30 min. before they were removed from the pressure vessel. After draining off excess liquor, several chips were cut open for visual inspection of penetration. It was found that penetration was irregular, in many cases there being no trace of liquor near the chip centers. Therefore, this method of pre-impregnation was discarded.

Further testing proved that submergence of the air-dry chips in cooking liquor at room temperature for 6 hr. resulted in good penetration. Both shredded and mill-size chips were impregnated in this manner. The shredded chips, after impregnation and draining,

Table III. Preliminary Pulping of Spruce by the Ammonium Bisulfite Process

Cook no.	Cooking time, min. To max. temp.	Cooking time, min. At max. temp.	Max. temp., °C	Max. total pressures, p.s.i.g.	SO_2 in cooking liquor, % Total	SO_2 in cooking liquor, % Comb.	Yield, % of O.D. wood Total	Yield, % of O.D. wood Screened	Screenings, % of total yield	Lignin, % in Pulp	Lignin, % in Screenings	D.P. of pulp lignin free)
Mill-Size Chips—No Impregnation												
3094	360	0	148	96	5.2	1.2	58.9	46.6	39.7	8.8	18.9	...
3095	360	15	148	99	5.2	1.2	55.3	40.5	26.8	7.4	18.4	...
3096	360	35	148	99	5.2	1.2	53.3	43.6	18.0	6.0	11.5	2020
3097	360	55	148	101	5.2	1.2	50.9	46.6	8.3	3.9	11.9	2010
3098	360	85	148	103	5.2	1.2	50.2	45.7	4.7	2.9	17.2	1786
3099	360	−30	148	87	5.2	1.2	66.3	18.2	72.6	8.2	20.3	...
3100	360	0	148	98	5.2	1.2	59.8	34.1	43.1	8.5	19.8	...
3101	360	30	148	100	5.2	1.2	54.1	41.8	22.7	6.1	18.3	1916
3102	360	60	148	102	5.2	1.2	50.6	46.3	8.5	4.0	16.4	1885
3103	360	85	148	101	5.2	1.2	48.4	46.3	4.2	3.3	16.4	1777
Shredded Chips—No Impregnation												
3104	360	−30	148	86	5.2	1.2	62.5	17.4	72.2	14.3	16.1	...
3105	360	0	148	94	5.2	1.2	55.6	53.8	3.2	8.8	18.3	...
3106	360	15	148	96	5.2	1.2	52.8	52.1	1.3	7.1	21.2	2080
3107	360	30	148	96	5.2	1.2	51.2	50.9	0.4	4.8	...	2020
3108	360	45	148	98	5.2	1.2	49.9	49.7	0.2	3.5	...	1960
3109	360	−30	148	85	5.2	1.2	62.4	18.0	71.2	13.9	15.8	...
3110	360	0	148	90	5.2	1.2	57.9	38.3	33.8	12.0	15.2	...
3111	360	15	148	93	5.2	1.2	55.1	51.1	7.4	9.5	16.0	2165
3112	360	30	148	93	5.2	1.2	52.6	51.0	3.0	7.6	18.1	2110
3113	360	45	148	97	5.2	1.2	50.0	49.6	0.8	4.0	...	2025

7.0 liters of liquor used per 1000g. of O. D. wood.

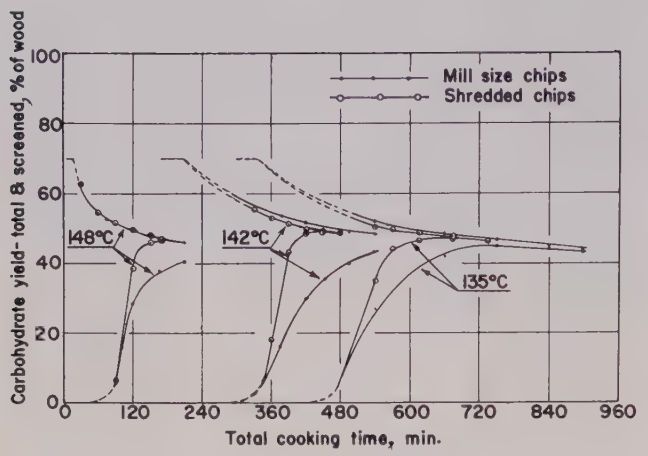

Fig. 1. Cooking curves—mill size and shredded chips

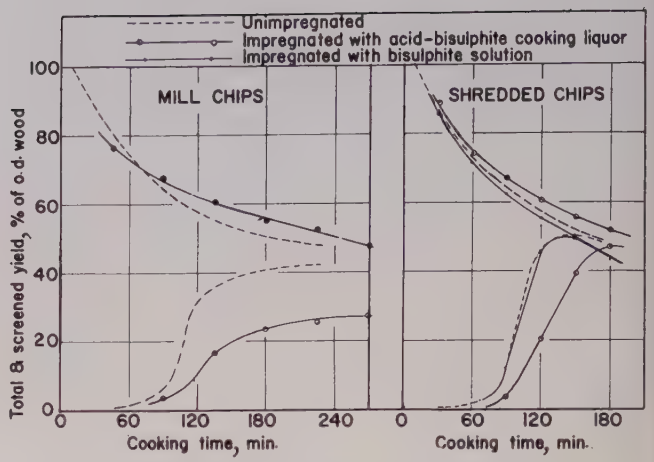

Fig. 2. Effect of pre-impregnation on pulping rate 30 min. to max. temp. of 148°C.

contained 61.8% total liquid, including cooking liquor and original moisture. These particular chips contained 6.4% moisture before impregnation. The mill-size chips, after soaking and draining, contained 49.7% total liquid. These chips had contained 11.6% moisture before impregnation.

A third set of pre-impregnation cooks was carried out on shredded chips alone, impregnating, in this case, with ammonium bisulfite solution only, with no sulfurous acid. The analysis of this liquor was 3.0% total SO_2, 1.5% combined SO_2. It was possible to impregnate these chips by submerging them in liquor, bringing the liquor to a boil and cooling to 60°C. while keeping them submerged. After draining, these chips contained 71.6% total liquid. They had contained 9% moisture before impregnation.

All of these impregnated cooks were carried out at a maximum cooking temperature of 148°C. with 30 min. to bring the cooks from room temperature to maximum temperature. Seven liters of fresh cooking liquor were added per 1000 g. ovendry wood, in addition to the liquor put into the chips by pre-impregnation.

All the cooks described are reported in Table I, and the cooking curves, both total and screened yield vs. total cooking time, are shown in Figs. 1 and 2. Figure 1 gives the cooking data for unimpregnated chips, and Fig. 2 the effect of pre-impregnation on the cooking curves.

Some of the preliminary cooking data are listed in Table III. These are the cooks for which 6 hr. was allowed for the digesters to reach a maximum temperature of 148°C., and which were not considered to have appropriate conditions for purposes of comparison. The cooking curves for these data, along with the data for the 142°C. cooks, are plotted in Fig. 5 to show the very marked effect of a 6°C. temperature rise on the pulping rate.

DISCUSSION

Effect of Chip Size and Temperature-Rise Period on Yield

The data in Table I and, more particularly, the cooking curves in Fig. 1, show clearly the effect of these two variables on the pulping reaction. It should be pointed out that, for each set of conditions used in cooking chips which had not been impregnated, all cooks were run in duplicate. This was done because some of the conditions used were quite unusual for acid bisulfite pulping and it was felt that maximum reliability of the data would be desirable.

In spite of this duplication, one value for the D.P. of the pulp produced from shredded chips with a 30 min. temperature-rise period is obviously out of line. In cook no. 3076 (Table I) the D.P. of the screened, delignified pulp is shown as 1609. Its duplication, in cook no. 3081, also has the very low value of 1602. These values were rechecked by additional viscosity determinations, with the same result. Obviously they do not represent the true cellulose chain length for the pulp. Whether it is impossible to evaluate correctly chain lengths in pulps containing as high as 18% lignin or whether some error in cooking conditions actually duplicated itself is not known. In any event, these values of D.P. should be considered as incorrect.

For each period of temperature rise studied it can be seen that the shredded wood attained maximum screened yield faster, and reached a higher value of maximum screened yield of better quality pulp (as indicated by D.P.) than was the case for mill chips. The following tabulation clearly shows these facts.

Time to max. temp., hr.	9.0	9.0	6.0	6.0	0.5	0.5
Type of chip	Mill	shredded	Mill	shredded	Mill	shredded
Time at max. temp., hr.	3.5	1.25	3.0+	1.0	3.0+	2.0
Max. screened yield, % of O.D. wood	46.6	49.3	44.8+	51.4	42.0+	50.6
Lignin content, % of moisture-free pulp	3.5	6.4	<3.0	6.1	<3.0	8.2
D.P. of cellulose	1523	1715	<1870	2011	<1600	1899

It is unfortunate that the cooks for mill-size chips at 6 and at 0.5 hr. to maximum temperature were not carried beyond the total cooking times listed. Maximum screened yield had not been attained in either case. The shape of the screened yield curve for 6 hr. to maximum temperature indicates that the maximum screened yield was almost reached. In the case of the cooks requiring 0.5 hr. to maximum temperature, it is doubtful if a continuation of the cook beyond the total of 3.5 hr. listed would have resulted in higher yield. An examination of the D.P. data for these cooks indicates that a condition of burning was being approached. In the last two cooks of the series the decrease in D.P. was too rapid for normal liquor conditions. Even though the liquor from the last cook

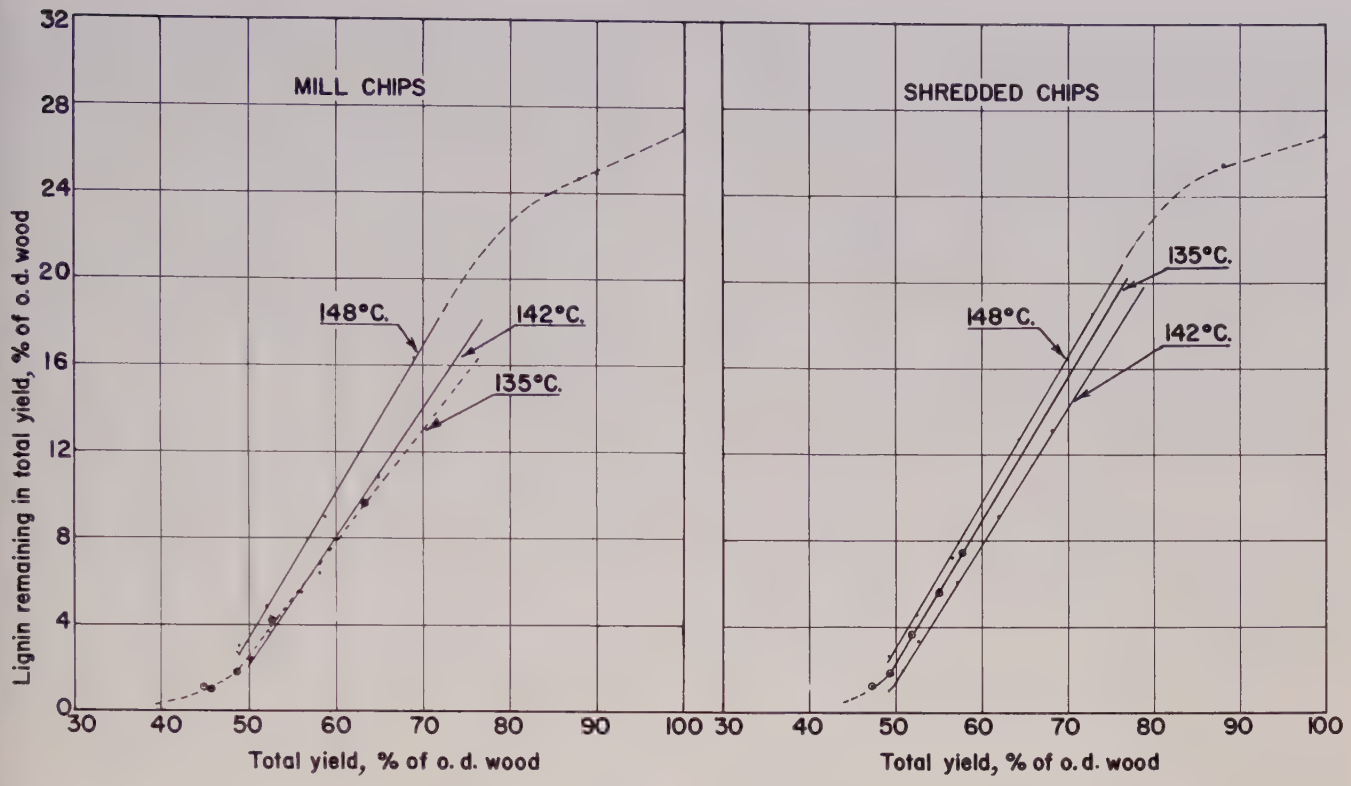

Fig. 3. Total lignin remaining in pulps

was still orange in color, the viscosity data indicate that the pH of the liquor might have been getting dangerously low.

The very pronounced effect of chip size on the shape of the screened-yield curve indicates that chip surface and distance from the surface to the center of the chip are as important as in kraft pulping. It points very definitely toward the probability that, even in rather extended temperature-rise periods, the liquor is not penetrating into the chip. Rather, the sulfonation and hydrolysis reactions, causing the solution of ligneous material, may be starting at the surface and eating their way toward the center.

This mechanism would explain the high peak in the screened-yield curves for shredded wood. With the very short distance from the surface to the chip center of these chips (0.03 to 0.13 in.), the innermost fibers of the chips could have been delignified to the point that they could appear as screened pulp early in the cook. Consequently, the carbohydrate material at the outer edges of the chip, being subjected to a comparatively short action by the liquor, would appear in the product as higher yield and quality. The overall result would be a high yield of screened pulp, with a relatively high lignin content and a long chain length. This is in agreement with the cooking data.

It has been argued in numerous publications over a period of years that sufficient penetration time must be allowed so that the cooking liquor, containing the combined sulfur dioxide, can follow the free sulfur dioxide, probably in the gaseous state, into the lumen of the fibers. It is doubtful that the free sulfur dioxide ever got into the lumen before reaction in any of the cooks reported here. This is particularly true in the cases where only 30 min. was allowed to reach maximum temperature.

This lack of penetration during a temperature-rise period can be explained by the following example: Consider a wood chip submerged in water in a closed container. The chip, before submergence, contains 50% water or 1 lb. of water per pound of wood. In the conifers, this water is mainly in the lumen of the fibers. It has been shown that chips, when completely saturated with water, will contain 2 lb. of water per pound of wood. Therefore, the lumen of the fibers, at 50% moisture, are half-full of water and half-full of air, or other inert gas.

As the temperature of the system is raised, heat is transmitted from the surroundings to the liquid and from the liquid to the chip. The vapor pressure of the liquid increases with its temperature. At the point of contact between wood and chip, the two phases at that point must have the same temperature. Consequently, the fibers at or near the surface are at the liquor temperature, the liquid water inside the lumen must be at that temperature, and the vapor pressure must be the same inside and outside the fibers. However, the total pressure inside the lumen must be greater than in the surrounding liquid because the lumen contains air as well as water. Since partial pressures are additive, the vapor pressure of water vapor and the gas pressure combine to bring about this increased pressure. Therefore, throughout the temperature-rise period, there could be a continuing outward movement of gas and vapor tending to equalize external and internal pressure. As long as this outward movement of gas and vapor continues there can be no mass liquid or gas movement into the chip.

When acid bisulfite liquor is substituted for the water in the example, the pressure of the liquid phase is made up of a partial pressure of sulfur dioxide gas as well as the vapor pressure of liquid water. In such a case, the total pressure of the liquid is greater than the pressure inside the fiber lumen. However, this pressure

differential is exerted on all sides of the chip, tending to compress the gas phase in the lumen rather than to displace it. The mass movement of sulfur dioxide gas and liquid should be slow since a mixture of gas bubbles and liquid slugs in tubes of capillary size will not flow as readily as a single phase.

If chips are submerged in liquid at constant temperature for several hours or if, as is done in sulfite practice, the digester is brought to 110°C. and then allowed to stand at this temperature for 2 or 3 hr., there will be a mass movement of liquid into the chips, brought about mainly by the hydrostatic pressure of the liquid over the chips. In the cooks in this report, however, there was no hesitation in the temperature-rise period to permit a penetration of free sulfur dioxide or cooking liquor.

It is a common belief that burning will occur early in the cook if the free sulfur dioxide is in contact with the lignin at elevated temperatures. The cooking conditions in these experiments, which used only 30 min. to reach 148°C., would be ideal for such early burning. The data show that no early burning occurred since good yields of high quality cellulose fiber were obtained. Therefore, it appears obvious that free sulfur dioxide could not have penetrated ahead of the liquid, and highly probable that delignification started at the surface and that the reactions, rather than the liquor, penetrated toward the center.

Lignin Contents of Pulps

The data in Table I include not only the lignin content of the screened pulp but also the lignin content of the screenings. From these lignin analyses and the yield data it was possible to calculate the lignin yield values listed in Table II and plotted in Fig. 3.

Figure 3 shows that lignin removal bears a straight-line relationship to total yield over much of the pulping range. As would be expected, at lignin contents of less than 2% on a basis of original wood (approximately 4.0% or less, expressed on a basis of pulp), the efficiency of lignin removal falls off drastically. It is interesting to note that the 148°C. line for mill chips is identical with the 148°C. line for the shredded chips. The two 142°C. lines are also very nearly identical. The 135°C. line for mill chips, shown as a dotted line, may not represent the true placement of the line. The magnitude of the total yield figures for the 135°C. work were such that the spread of the data points was not great enough to define the line accurately.

Figure 3 also shows that the placement of these lines on the chart, from left to right, is a measure of the efficiency of cooking, just as is the Ross diagram (*16*). Thus, the 142°C. line indicates that considerably more carbohydate or fibrous material is conserved for a given lignin removal than when 148°C. maximum temperature is used. However, this does not indicate that 148°C. must be, in all cases, a less desirable cooking temperature than 142°C. It is quite possible that different values than those used for liquor-to-wood ratio and concentration of free and combined sulfur dioxide may prove that 148°C. is just as efficient an operating temperature as 142°C.

The change in the absolute values of lignin content with cooking time, for both screened pulp and screenings is, perhaps, the most significant feature of these data. Let us first consider the lignin content of pulps made from mill chips, with a temperature rise schedule of 30 min. to 148°C. (Cook nos. 3084–3088, 3089–3093). After 90 min. at maximum temperature, the average lignin content of the screened pulp is about 10%. An additional cooking time of 45 min. reduced the average lignin content to 5.7 and 4.9, or an average of 5.3%. During this same period, per 100 g. of ovendry wood, an additional weight of (9.0 + 5.9)/2 or 7.5 g. of fresh pulp was being added to the previously realized 31.7 g. of screened pulp. During this same period, the weight of screening diminished but the lignin content of these screenings remained substantially constant, in the range of 20 to 22%.

From these data it is quite apparent that the fibers, at some lignin content between 20 and 10%, lose sufficient adherence to the chip body so that they become detached from the chip either before or during the blow, and appear in the product as screened pulp. An examination of all the cooking data will permit a narrowing of this range of lignin content which permits the release of screened pulp. Cooks no. 3076 and 3081, for shredded chips, were so raw that they contained less than 10% of screened pulp. The lignin content of this pulp was 18%. This value would appear to be very close to the limit of lignin content which will permit the fibers to become detached from the main body of the chip.

If the fibers, at the moment they become part of the screened yield, contain about 18% lignin, but the overall mass of screened fibers contains, on the average, 5 to 10% lignin, it appears obvious that a fairly high fraction of the total fibers must contain little or no lignin. If, now, it is granted that the chips retain their original size and shape up to the point of blowing, these chips can be pictured as having a soft, porous mass at the outside of the chip, with hard, uncooked centers. There must be a lignin gradient across this outer band of porous material, varying from 0% at the outside of the chip to as high as 18% at the hard, center core. The core itself, from an examination of the lignin analysis data, will contain an average of from about 18 to 25% lignin. Such conditions are indicative of an inward moving reaction interface.

An examination of the screenings resulting from various degrees of cooking gives further evidence supporting this moving reaction idea. Early in the cook, the screenings consist of practically the whole chip. The outer surface is very light-colored, almost white, and soft. Cutting through a cross section of the chip, we find that the chip centers appear to be unaltered wood. Just inside the soft outer edges there is a somewhat soft, light-colored band. Upon standing in air the section becomes darker, except for the untouched center.

As cooking continues, the cross sections of the screening particles become progressively smaller. The length in the grain direction remains almost as long as the original chip. This can be explained by the cooking reaction moving inward at the same velocity in all three planes. Since most chips are relatively long and wide but comparatively small in thickness, it is this thickness which determines cooking time. If a chip were about $^3/_8$ in. thick and $^3/_4$ in. long, it would be expected that the screenings would also be long in the

grain direction. This is contrary to what would be expected if the process were controlled by liquid penetration, since it has been established that penetration is about 100 times more rapid in the grain direction than across the grain.

Carbohydrate Yield of Pulps

The carbohydrate yield was calculated from the yield and lignin analysis data in Table I and are listed in Table II. It was assumed that the yield was made up of carbohydrate and lignin only. Its numerical value may be slightly in error, depending on the amount of water solubles that might remain in the uncooked screenings.

The carbohydrate-yield data, both total and screened, are plotted against cooking time for both mill-size and screened chips in Fig. 4. They are quite similar in shape to the pulp yield curves in Fig. 1. It can be seen that considerably more carbohydrate can be recovered in the pulp if shredded, instead of mill-size, chips are used. The principal reason for including Fig. 4 in the presentation is to prove that the increased yield of screened pulp from shredded chips is not due only to the high lignin content of the screened pulp.

Pentosan Content of Pulps

It was not a purpose of this investigation to compare the pentosan removal of the experimental pulping with usual pulping procedure. However, a few pentosan determinations were made on the pulp produced with the rapid temperature-rise period of 30 min. to maximum temperature. These analyses are listed as follows:

Cook no. →	*3084*	*3086*	*3089*	*3091*	*3074*	*3076*	*3079*	*3081*
Pentosan in screened pulp, %	...	4.8	...	4.3	...	4.1	...	4.2
Pentosan in screenings, %	6.7	4.4	6.2	4.3	6.2	4.7	6.4	4.4

It is interesting to note that the pentosan content of the screenings, whether from mill-size or shredded chips, is substantially the same as for the screened pulp. It cannot be stated whether this loss of pentosan within the chip itself is caused by a solubilizing in water at high temperature or by an acid hydrolysis brought about by the formation of wood acids. If it had been caused by excessive acidity from free sulfur dioxide within the chip, early burning of the cook would have resulted.

Degree of Polymerization of Pulps

Attempts were made to present the data on D.P. graphically, plotting the log of D.P. vs. cooking time. Such a plot, in kraft pulping, developed some interesting straight-line relationships. In this case, however, the time span over which viscosity measurements could be made was such a small fraction of total cooking time that no significant relationship could be developed from the data.

The data show definitely that less degradation and, consequently, higher quality cellulose will be realized if shredded chips are used instead of the mill-size variety. This is caused entirely by the shorter time which the pulp is in contact with the cooking chemicals.

Effect of Pre-impregnation on Pulping

Table I shows the results of pre-impregnating both

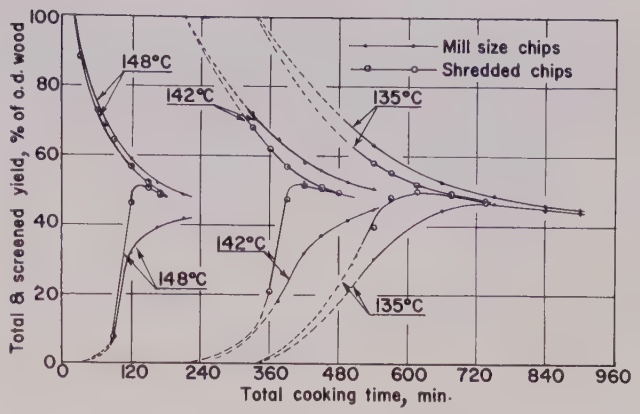

Fig. 4. Carbohydrate yield in pulps

shredded and mill-size chips with cooking liquor before cooking, and the cooking curves are shown in Fig. 2. For reference purposes, the cooking curves for similar cooking conditions without impregnation are shown in Fig. 2 as dotted lines. The pre-impregnation tests were carried out only on those cooks which were brought to maximum temperature in 30 min.

The results are quite surprising. The pre-impregnation caused a very substantial decrease in reaction rate for both shredded and mill-size chips. With the information at hand it is impossible to explain this effect. It is unfortunate that duplicate cooking was not used in this instance. However, the fact that the reduced reaction rate took place for both shredded and mill-size chips reduces the probability that an error of procedure may have occurred.

When shredded chips were pre-impregnated with ammonium bisulfite alone, instead of with both free and combined sulfur dioxide, this slowdown did not occur. In fact, the pre-impregnation appeared to have no effect on rate of pulping. However, the introduction of chemical into direct contact with the cellulose through impregnation appeared to have a slight degrading effect. This is indicated by the fact that the pre-impregnated chips cooked 120 min. Cook no. 3251 had a cellulose D.P. of 1680 as compared to 1899 for the unimpregnated chips cooked for the same length of time (Cook no. 3078). This loss in D.P. cannot be attributed to burning because, even in Cook no. 3250, where maximum temperature was maintained for only 90 min., the cellulose D.P. was about 250 points lower than the corresponding cook without pre-impregnation. Also, the color of the blown liquors was too light to give any indication of burning. For the whole series of cooks, the color of the liquor at the end of each cook was as follows:

Cook no.	*Liquor color*
3248	yellow
3249	yellow-orange
3250	yellow-orange
3251	orange
3252	orange-red

There was no trace of turbidity in any of these liquors.

This same loss in D.P. was also observed when the impregnating liquor was the same liquor as that used in cooking. With the shredded chips, the loss was of

about the same magnitude as in the case when bisulfite was the impregnating liquor. The following listing of liquor colors at the time of blowing indicates that no burning occurred:

Cook no.	*Liquor color*
3236	yellow
3237	yellow
3238	yellow
3239	light-orange
3240	orange-red

All liquors were slightly turbid. After standing overnight, the liquors became clear, with a fine white precipitate on the bottom of the flask. This material was separated and dried. It was found to be soluble in carbon disulfide, indicative of colloidal sulfur. This was undoubtedly formed from the autoxidation-reduction of sulfur dioxide to sulfur trioxide and elemental sulfur which occurs in acid bisulfite liquors at elevated temperatures.

An even more marked loss in D.P. was found in the cooks for mill-size chips after pre-impregnation with cooking liquor. This loss, however, cannot be attributed entirely to the presence of liquor in direct contact with the cellulose throughout the cook. The presence of the liquor inside the fiber had, as mentioned earlier, caused a slowdown in pulping rate. This required extended cooking times, 60 min. beyond the range of the cooks without pre-impregnation. The increase in time at maximum temperature, in turn, caused increased amounts of sulfur dioxide to be converted to sulfur trioxide and sulfur through the autoxidation-reduction reaction.

The autoxidation-reduction reaction does not consume base. Rather, it increases hydrogen ion concentration as the sulfur trioxide and water ionize to H^+ and HSO_4^-. As the HSO_4^- ion increases it replacesH SO_3^- ions from the dissociated sulfurous acid, releasing more sulfur dioxide to the gas phase. As a result, the pH of the solution decreases, degradation of cellulose increases and, probably, condensation of lignin, or burning, takes place. The following listing of liquor colors at the time of blowing bears this out:

Cook no.	*Liquor color*
3242	yellow
3243	orange
3244	orange-red
3245	brown
3246	black

General Discussion of Process Variables

The data in this paper indicate that the long periods of temperature rise usually employed in acid bisulfite pulping are unnecessary. Also, it appears unnecessary to hold chips and liquor at 110°C. for periods of 1 to 3 hr. to provide impregnation of the chips with liquor. It has been shown that the digester can be brought to maximum temperature in 30 min. if proper adjustment of chip size is made.

If this higher speed cooking cycle is to be used successfully, chip size must be adjusted to provide the maximum surface for reaction and the shortest possible path from the outside of the chips to the chip centers. This can best be accomplished by splitting long chips ($^3/_4$ in. or longer, in the grain direction) along the grain rather than by resorting to very short chips. Such splitting has been proved to cause little or no fiber breakage, if properly controlled. A reasonably good

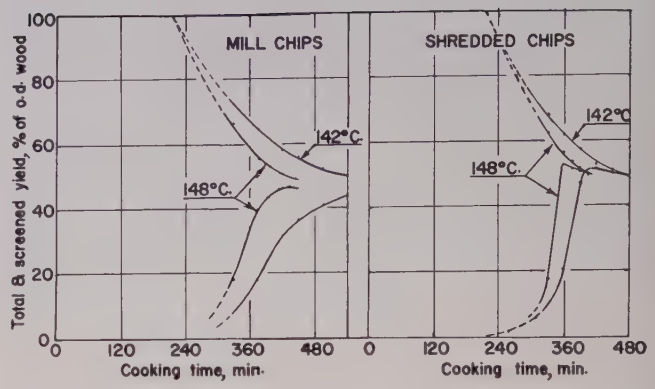

Fig. 5. Effect of temperature on pulping rate

6 hr. to max. temperature

subdivision would be one in which the product would pass, endwise, through 3-mesh screen and be retained on 10-mesh. If this splitting, or shredding, is carried out so that all the shredded product passes through 3-mesh screen there will be a very high percentage of fines in the product, indicative of excessive fiber damage. It is much better, as a rule, to adjust the attrition mill or other device used in shredding, so that 30 to 35% of the product is oversize. This oversize portion should be screened out and returned to the shredder. Under such circumstances, the fines (material passing 10-mesh) can be controlled to 1 to 2% of the product.

For high-speed operation it is also necessary to carefully adjust temperature, concentration of liquor, and liquor-wood ratio. It has been pointed out that, as the temperature-rise period is decreased, the amount of delignification which can be carried out during this temperature-rise period will decrease. This may amount to a very appreciable fraction of the total delignification. Miller and Swanson (7) showed that in a cook requiring 9 hr. to reach maximum temperature, 60% of the total delignification took place in the temperature-rise period. Therefore, as the time to maximum temperature is decreased the time at maximum temperature increases. Consequently, the autoxidation-reduction reaction will build up an increasing hydrogen ion concentration, and burning can result.

Increased concentrations of sulfur dioxide and increased liquor-to-wood ratio appear preferable to increased temperature in bringing about an accelerated reaction rate to decrease time at maximum temperature. Increased temperature will increase the rate of sulfur dioxide decomposition as well as the rate of delignification. Data on the kinetics of the two reactions will indicate just how effective the temperature variable is for decreasing time at maximum temperature. In any event, the cooking variables must be so adjusted that the time at maximum temperature will not produce excessive acidity near the end of the cook.

Some indication of the effect of temperature on the rate of pulping can be obtained from an examination of Fig. 5. The cooking curves are plotted for both 142°C. and 148°C. maximum temperature, using 6 hr. to reach maximum temperature. The data for 148°C. are listed in Table III, while the data for 142°C. can be found in Table I.

Using shredded chips, it can be seen that the maxi-

mum screened yield for the 148°C. cook is reached at a total cooking time of between 360 and 375 min. The screened yield, for these conditions, should be as high as 52 to 53%, with a lignin content of about 9% and a cellulose D.P. of better than 2000. Using a maximum temperature of 142°C., between 15 and 30 min. of additional time is required, screened yield decreases by 1 to 2% and cellulose quality is slightly less.

With mill-size chips, this 6°C. temperature rise will cut 2 hr. off the time at temperature, increase screened yield by 1 to 1.5%, increase lignin content by about 1% and improve cellulose quality.

It is, therefore, apparent that the temperature variable should be explored thoroughly whenever a change in a temperature rise schedule, chip size, or liquor concentration is contemplated. Usually an increase in maximum temperature will improve pulping efficiency, up to the point where autoxidation-reduction becomes sufficiently rapid to cause excessive acidity and burning.

CONCLUSIONS

From the experimental evidence contained in this report, the following conclusions appear warranted.

1. Acid bisulfite pulping can be carried out without penetration of the cooking liquor into the chips before the lignin sulfonation and hydrolysis start.

2. It therefore becomes possible to carry out the pulping process in much shorter cooking times, reducing the time required to reach maximum temperature to as low as 30 min.

3. Chip size must be adjusted to decreased cooking cycles, decreasing chip size in the cross-grain direction rather than in length along the grain.

4. The data indicate that the delignification reactions start at the chip surface and move from the chip surface toward the chip center just as has been previously found for alkaline pulping.

5. Pre-impregnation of the chips with cooking liquor appears to slow down the pulping reaction and result in cellulose of somewhat shorter chain length when compared to pulp cooked without pre-impregnation.

6. Burning late in the cook appears to be caused by an increase in hydrogen ion concentration brought about by the autoxidation-reduction of sulfur dioxide to sulfur trioxide and sulfur rather than by a depletion of NH^{-}_{4} ions.

7. The data indicate that it should be possible to carry out continuous, constant temperature pulping by the acid bisulfite process without resorting to pre-impregnation of the chips with cooking liquor.

LITERATURE CITED

1. Ericsson, E. O., McCarthy, J. L., and Pearson, D. A., "The College Textbook of Pulp and Pulp Manufacture," Chap. IX, 18: Technical Association of the Pulp and Paper Industry, 360 Lexington Ave., New York, N. Y., 1960.
2. Palmrose, V. G., *Tech. Assoc. Papers, series* XVIII, No. 1: 309–310 (1935).
3. Harvin, R. L., Hills, G. B., Jr., Rockroth, C. W., Jr., and Nolan, W. J., *Tappi* 33, No. 7: 338–34 (1950).
4. Nolan, W. J., *Tappi* 42, No. 4: 320–327 (1959).
5. Jayme, G. and Lockmuller-Kerler, E., *HolzRoh-u. Werkstoff* 6, 274–7 (1943).
6. Strapp, R. K., *Pulp and Paper Mag. Can.* 56, No. 3: 179–185 (1955).
7. Miller, R. N. and Swanson, W. H., "The Chemistry of the Sulphite Process," Chap. 1–17: Lockwood Trade Journal Co., New York, N. Y., 1928.

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Sulfate-Reducing Bacteria, Their Production of Sulfide and Their Economic Importance*

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Sulfate-reducing bacteria are widely distributed in nature, in soil, water, and sewage. They are anaerobes that reduce sulfate to sulfide while growing on diverse organic compounds. They oxidize certain organic acids but not cellulose and derive nitrogen from ammonium, some amino acids, and molecular nitrogen. They develop in reactions from pH 5.5 to 9.0 and at both low and high (55°C.) temperatures. Some cultures produce spores. They may develop in association with other bacteria to cause staining of paper pulp by iron sulfide, and to corrode iron and steel of pipelines, tanks, and pumps. Pulp wastes discharged into streams and water basins promote development of the bacteria resulting in production of hydrogen sulfide in quantity. Control of development is effected by germicides, regulation of pH, aeration, and elimination of the supply of organic nutrients of the bacteria. Control of corrosion can be effected also by insulation and cathodic protection of the metal.

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Sulfate-reducing bacteria are not strangers to manufacturers of wood pulp, paper pulp, and paper because conditions are favorable for development of these bacteria within the producing plants. Furthermore the waste waters contain substances that promote growth of the bacteria in the receiving waters and the river sediments. Although they are not the only microorganisms that produce sulfide they are one of the principal producers of the substance and are suspected wherever sulfide occurs in nature in large amounts.

Within the plant they may develop in storage tanks or on pipe surfaces covered with sediment or slime, that promote anaerobic decomposition of cellulose or other carbohydrates. Blackening of paper pulp from gelatinous material containing iron sulfide that broke away from pipes was noted by Beckwith and Moser (*3*). Staining is not the only objectionable result of development of the bacteria on the surface of cast iron and steel. Their development promotes corrosion with is frequently rapid and destructive. Nevertheless where

equipment is kept clean and there is no prolonged storage of cellulosic material there may be little development of sulfate-reducing bacteria. Likelihood of development is reduced further where germicides are used. Because some sulfate-reducing bacteria are thermophilic it is uncertain whether the high temperature (50 to 60°C.) of the circulating pulp serves to control sulfate reduction.

Problems from sulfide production are more common in the bodies of water that receive wastes of wood pulp and paper pulp. The receiving waters may not move the waste material away rapidly, and cellulose may settle from the waters and accumulate in the sludge on the river bottom as where water is retained in ponds behind dams. Soluble organic matter, including carbohydrates, and suspended material promote microbial development, resulting in lowered oxygen content. The sludge may at times undergo rapid microbial development particularly in midsummer during periods when water is low and warm. At these times sulfide may be produced so rapidly that hydrogen sulfide is released from the water into the air and becomes a nuisance. The odor is objectionable, paint becomes discolored, and animal and plant life in the water is destroyed because of lack of free oxygen. Deficiency in oxygen is caused by microbial attack of decomposable organic matter in the waste water, and also by oxidation of sulfite whenever large quantities are discharged in the waste water.

Undesirable effects are widespread in rivers into which wastes have been discharged, the degree of the effects varying with the volume and quality of waste, the degree of dilution in the receiving waters, and the rate of flow. Problems have been encountered recently in the northwest (*10, 29*) and northeast (*16–19*), and an extensive program of study of bacterial sulfate reduction was undertaken in Japan as a result of sulfide production in coastal waters polluted with pulp mill wastes (*12–15*).

SULFATE-REDUCING BACTERIA*

Factors Affecting Their Development

Sulfate-reducing bacteria are widespread in nature and will generally develop wherever there is a supply of the required nutrients and where environmental conditions are favorable. Because they are strict anerobes their development is promoted by readily decomposable organic matter, development of associated microorganisms, and reducing agents.

They are unique because they can reduce sulfate to sulfide. The sulfate serves as the oxidizing agent for various organic compounds which are the sources of energy and carbon for growth. There are only three well-characterized sulfate-reducing bacteria, all of which are curved cells (vibrios). The most common and best known is *Desulfovibrio desulfuricans* which is a mesophilic nonspore-forming, motile, curved rod. There are also two spore-forming cultures, *D. orientis*, which is mesophilic, and *Clostridium nigrificans*, which grows best at 55 to 60°C. An organism similar to, if not the same as, *D. desulfuricans*, isolated from the marine environment has been designated *D. aestuarii*. Little is known of the occurrence of the spore-forming species but consideration should be given to the temperature tolerance of these bacteria and the resistance of their spores in planning control measures.

They develop best at reactions close to neutrality (pH 5.5 to 9.0) at strongly reducing conditions (E_h = −200 mv.) and satisfy their nitrogen requirements from ammonium nitrogen and some amino acids. Some strains of *D. desulfuricans* can use atmospheric nitrogen (nitrogen fixation). Sulfate is required in quantity because it is not only assimilated but serves as the oxidizing agent of metabolized organic compounds. Sulfite, thiosulfate, and tetrathionate can substitute for sulfate. The most commonly used organic compounds are the following acids: lactic, pyruvic, malic, fumaric, and succinic. There is lack of agreement on the number and kinds of organic compounds that can be utilized, but it has been reported that hexoses, alcohols, amino acids, and other compounds are oxidized. There may be differences in the kinds of organic substances that are utilized by different strains of the bacteria. Sulfate-reducing bacteria are unable to attack cellulose but they are commonly encountered where cellulose is undergoing anaerobic decomposition. Under this condition organic acids, and possibly also molecular hydrogen produced by the anaerobic cellulose-decomposing bacteria, are the substrates for development of the sulfate-reducing bacteria. As shown by the following equations, there is a stoichiometric relationship between the amounts of organic compound oxidized, sulfate reduced, and sulfide produced. Furthermore, acetate is a common product and it is not oxidized by *D. desulfuricans*.

$$4(HOOC\cdot CH_2\cdot CH_2\cdot COOH) + 3Na_2SO_4 = 4(CH_3\cdot COOH) + 8CO_2 + 3Na_2S + 4H_2O$$

Succinate

$$2(HOOC\cdot CH{:}CH\cdot COOH) + Na_2SO_4 = 2(CH_3\cdot COOH) + 4CO_2 + Na_2S$$

Fumarate

$$2(HOOC\cdot CH_2\cdot CHOH\cdot COOH) + Na_2SO_4 = 2(CH_3\cdot COOH) + 4CO_2 + Na_2S + 2H_2O$$

Malate

$$2(CH_3\cdot CHOH\cdot COOH) + Na_2SO_4 = 2(CH_3\cdot COOH) + 2CO_2 + Na_2S + 2H_2O$$

Lactate

$$4(CH_3\cdot CO\cdot COOH) + Na_2SO_4 = 4(CH_3\cdot COOH) + 4CO_2 + Na_2S$$

Pyruvate

Most cultures of *D. desulfuricans* also oxidize molecular hydrogen, which promotes their growth. This has significance in anaerobic corrosion of cast iron and steel according to one theory, as will be indicated subsequently. Because they can grow on various organic compounds at temperatures up to 60°C. or higher, and in solutions with salt concentrations up to 10% or more, they are adapted to diverse environments in nature and in industrial installations. Furthermore, they produce and tolerate high concentrations of hydrogen sulfide. Under laboratory conditions as much as 2000 p.p.m. of dissolved H_2S was produced in experiments conducted by Miller (*20*). Because the bacteria produce large amounts of sulfide they are conspicuous by the obnoxious odor of H_2S and the blackening of waters, soils and bottom material of ditches, lakes, estuaries, bays, and oceans through formation of iron sulfide.

* The morphology, taxonomy, physiology, and biochemistry of sulfate-reducing bacteria, their distribution and practical importance have been the subjects of recent reviews (*1, 6, 7, 21, 22, 25, 26, 27*) to which the reader is referred for detailed information.

Enumeration of the Bacteria

Occurrence and abundance of sulfate-reducing bacteria in muds, sludge or other materials has been determined by cultural procedures using elective culture media. In common with other strict anaerobes, development is promoted by use of reducing substances in the medium, which provide a redox potential of about −200 mv. Where numbers of sulfate-reducing bacteria were determined by use of media lacking strongly reducing substances, only 1 to 0.001% of the population could be detected (*11*). Therefore, growth develops only from heavy inocula in such media. The following medium in which cysteine is the reducing agent was found by Drummond and Postgate (*9*) to be satisfactory:

Sodium lactate	3.5 g.
Yeast extract (Difco)	1.0 g.
Cysteine hydrochloride	0.8 g.
K_2HPO_4	0.5 g.
NH_4Cl	1.0 g.
Na_2SO_4	0.5 g.
$MgSO_4 \cdot 7H_2O$	2.0 g.
$CaCl_2 \cdot 2H_2O$	0.1 g.
$(NH_4)_2Fe(SO_4)_2 \cdot 6H_2O$	0.4 g.
Distilled water	1000 ml.

It is adjusted to pH 7.5, sterilized at 1 atm. steam pressure, and used in 60-ml. glass-stoppered bottles, which are completely filled after inoculation and incubated at 30°C. Drummond and Postgate (*9*) incubated culture tubes containing 5-ml. portions of medium, and inoculated with 0.5-ml. portions of diluted material in anaerobic jars containing H_2 (5%) in CO_2. Sulfate reduction is evident as blackening in 1 to 7 days owing to reaction of the produced hydrogen sulfide with the dissolved iron. Since sulfide may be produced from cysteine by microorganisms other than sulfate-reducing bacteria it is important to test positive cultures for sulfide production in a medium devoid of cysteine. For this purpose transfers of 1-ml. portions of the culture solution are added to bottles of the lactate medium lacking cysteine, after the primary cultures have developed.

Counts were found to be higher where, in preparing the inoculum, the source material was diluted with liquid containing reducing material than when water alone was used as the diluent. It was noted by Butlin, *et al.* (*5*), that there was less interference from bacteria other than sulfate reducers where $Na_2SO_3 \cdot 7H_2O$ was included in the cultural media at a level of 3%.

Economic Importance of the Bacteria

In addition to their above-mentioned objectionable and destructive effects as producers of sulfide, they blacken metals, spoil food, and corrode iron and steel. In oil fields they corrode pipes, pumps, and storage tanks and interfere with disposal of produced water and flooding of petroleum formations for recovery of oil, by clogging the pore spaces of the strata with iron sulfide and bacterial cells. Great quantities of fish are destroyed in some local areas of the ocean through development of the bacteria following inversion of the deep waters, or disturbance of the ocean bottom.

They are corrosive through processes of both acid and anaerobic corrosion. In the former process they produce sulfide, which becomes oxidized to sulfuric acid and is the corroding agent. The condition develops in partially filled tanks and pipes of concrete, steel, or cast iron containing material undergoing anaerobic decomposition. Sulfide produced by the bacteria escapes from the liquid, is adsorbed on the moist walls above the liquid, and becomes oxidized to sulfuric acid under the aerobic conditions on the walls, in part chemically and in part by sulfur bacteria including the sulfur-oxidizing bacterium *Thiobacillus thiooxidans*.

Anaerobic corrosion occurs at reactions near neutrality because of corrosion cells established by sulfide production. The strongly reducing areas of the metal surface where sulfide is produced become anodic to other areas which are free from sulfide, or are bathed with oxygen-containing water. The condition is commonly encountered in waterlogged areas of soils, fresh and salt waters, and industrial equipment. The external surfaces of pipes passing through areas of waterlogged soils become the seat of development of sulfate-reducing bacteria and are anodic to adjacent portions of the pipe passing through soil that is aerobic. Areas beneath tubercles or deposits on the inner surfaces of pipes or tanks, or beneath fouling organisms and layers of corrosion products of steel exposed in sea water, are also sites of anaerobic corrosion. Thus, corrosion is encountered in water pipes, pumps, steel piling in harbors, and on chains, buoys, and hulls of ships. Decomposable organic matter in contact with the metal increases the rate of corrosion. The large number of sulfate-reducing bacteria and the large amounts of sulfide in the black corrosion products serve as evidence of sulfate reduction.

During the corrosion process, hydrogen accummulates at the cathodic areas, and this must be removed for corrosion to continue. Under aerobic conditions it reacts with dissolved oxygen to become water. According to one explanation of the mechanism of anaerobic bacterial corrosion, the role of the sulfate-reducing bacteria is oxidation of the cathodic hydrogen by sulfate. As has been mentioned previously, molecular hydrogen is oxidized by many cultures of *D. desulfuricans*. Nevertheless, whereas anaerobic corrosion may be due in part to oxidation of the cathodic hydrogen, this fails to explain why there is only mild corrosion of specimens surrounded entirely by strongly reducing material and supporting an active population of sulfate-reducing bacteria, whereas there is severe corrosion of similar materials located partly in the anaerobic environment and partly in an aerobic one.

Anaerobic corrosion causes pitting of steel and graphitization of cast iron. With loss of metal from cast iron there is a soft residue consisting largely of carbon and iron sulfide.

Control of anaerobic corrosion is accomplished in various ways based on protection of the metal, or by providing conditions unfavorable for development of sulfate-reducing bacteria. The metal can be insulated with paint, bitumen, or concrete, and protected also by being made cathodic by application of direct current or by being connected to wasting electrodes of metals less noble than iron. Development of the bacteria can be brought about by aeration, adjusting the reaction to unfavorable levels ($pH < 5.0$ or > 9.0) and by use of germicides or inhibitors such as free chlorine, chromate, dyes, formaldehyde, quaternary ammonium compounds, chlorinated phenols, cyanide, and piperazine derivatives (*4*, *9*, *24*). Insulation and cathodic protection are widely used on pipes and struc-

tures buried in soil or submerged in sea water, whereas germicides are better adapted to use with material being circulated or stored in pipes and tanks. Sulfate reduction can also be prevented by excluding sulfate or its equivalent (sulfite, thiosulfate); but this can be accomplished infrequently. Although unrelated to corrosion, development of sulfate-reducing bacteria was controlled in the Androscoggin River in Maine, in which pulping wastes are discharged, by adding large quantities of nitrate (*17*). The nitrate served as the oxidizing agent and was reduced to ammonia. According to Lawrence (*16*, *17*), 641.5 tons of sodium nitrate was added to the river in 144 days, with good results.

Although sulfate-reducing bacteria are frequently pests, this is not invariably the case. They are presumed to have been responsible for the formation of some metal sulfide ores, to have played a major role in the production of the vast deposits of elemental sulfur that occur in deep sediments near the Gulf of Mexico, and it has been suggested that they were concerned in formation of the natural deposits of petroleum.

The contribution of the sulfate-reducing bacteria to the production of elemental sulfur is presumed to have been reduction of sulfate to sulfide in areas of deep strata sealed by overlying sediments. Subsequently, the sulfide became oxidized to sulfur by some chemical reaction. There is lack of agreement as to the reaction involved. A similar type of process has resulted in deposition of sulfur in surface sediments in coastal areas of India that become flooded periodically (*28*). During flood periods sulfide is produced by sulfate reduction. When the free water drains away at periods of low water, and aerobic conditions are restored, the sulfide is oxidized to sulfur. This has resulted in accumulation of sulfur to a maximum of 35% in some clay soils.

Sulfate-reducing bacteria were also implicated in the formation of sulfur which accumulated in large quantities in the lakes of Libya. According to Butlin and Postgate (*6*, *22*), sulfate which entered the lakes from water draining from the surrounding land was reduced to sulfide by the bacteria, and the sulfide was oxidized by photosynthetic sulfur bacteria which occurred in abundance in the lakes. Dead cells of these latter bacteria were believed to be the source of energy for the sulfate-reducing bacteria.

This type of process was the basis of a method proposed by Butlin, Postgate, *et al.* (*6*, *8*, *22*, *23*), for industrial production of sulfur. Sewage sludge, waste liquors of yeast and citric acid plants, or other industrial wastes, or elemental hydrogen, serve as the substrates for development of the sulfate-reducing bacteria under anaerobic conditions. The hydrogen sulfide was removed by passage of gas through the liquid, and oxidized chemically to sulfur. Elemental sulfur is so cheap that the process has promise of practical value only where it can be incorporated as part of a system for waste or sludge digestion or where sulfur is in short supply. It is poorly adapted for use with methane fermentation of sludge because the methane bacteria are sensitive to sulfide. They are inhibited by 150 to 200 p.p.m. of sulfide. Nevertheless, if the hydrogen sulfide is kept at a low level by being removed by passage of gas, such as a mixture of CH_4 and CO_2, the toxic effect of sulfide is reduced. In any case there is competition between the methane-producing bacteria and sulfate-reducing bacteria for the organic materials which support development of both bacteria. Consequently, growth of each is reduced to the extent that the other develops.

Bannink and Muller (*2*) used a similar process to remove sulfite from liquors from digestion of straw for production of cardboard and paper pulp; but the sulfide was not converted to molecular sulfur. The waste was digested anaerobically with production of methane and sulfide, and the sulfide was removed by reaction with iron hydrate. All of the sulfite disappeared during the anaerobic digestion.

LITERATURE CITED

1. Anonymous. "Sulfate-Reducing Bacteria. Their Relation tion to the Secondary Recovery of Oil," Science Symposium, St. Bonaventure Univ., St. Bonaventure, N. Y., 1957.
2. Bannink, H. F. and Muller, F. M., Antonie van Leeuwenboek, *J. Microbiol. Serol.* 18: 45–54 (1952).
3. Beckwith, T. D. and Moser, J. R., *J. Bacteriol.* 24: 43–52 (1932).
4. Beerstecker, E., Jr., "Petroleum Microbiology," Elsevier Press, Inc., N. Y., 1954.
5. Butlin, K. R., Adams, M. E., and Thomas, M., *J. Gen. Microbiol.* 3: 46–59 (1949).
6. Butlin, K. R. and Postgate, J. R., "Microbiological Formation of Sulfide and Sulfur," in "Symposium, Microbial Metabolism," Sixth International Congress of Microbiology, Rome, 1953.
7. Butlin, K. R. and Postgate, J. R., "Formation enzymatique de sulfure a partir de substrats minéraux par les microorganisms," Colloque sur la Biochimie du Soufre (Centre National de la Recherche Scientifique (Paris), pp. 61–74, 1956.
8. Butlin, K. R., Selwyn, S. C., and Wakerley, D. S., *J. Appl. Bacteriol.* 19: 3–15 (1956).
9. Drummond, J. P. M. and Postgate, J. R., *J. Appl. Bacteriol.* 18: 307–311 (1955).
10. Eldridge, E. F. and Orlob, G. T., *Sewage and Ind. Wastes* 23: 782–795 (1951).
11. Grossman, J. P. and Postgate, J. R., *Proc. Soc. Appl. Bacteriol.* 16: 1–9 (1953).
12. Hata, Y., *J. Shimonoseki Col. Fisheries* 9: 329–345, 347–362, 363–375; 10: 57–77, 79–87 (1960).
13. Hata, Y., Miyoshi, H., Kadota, H., and Kimata, M., *J. Shimonoseki Col. Fisheries* 8: 135–145 (1959).
14. Kimata, M., Kadota, H., and Hata, Y., *Bull. Japan Soc. Sci. Fisheries* 21: 229–234, 235–239 (1955).
15. Kimata, M., Kadota, H., Hata, Y., and Tamiya, T., *Bull. Japan Soc. Sci. Fisheries* 21: 102–108, 109–112, 113–118 (1955).
16. Lawrence, W. A., *Sewage Works J.* 20: 881–896 (1948).
17. Lawrence, W. A., *Sewage and Ind. Wastes* 22: 820–832 (1950).
18. Lawrence, W. A. and Fukui, H. N., *Sewage and Ind. Wastes* 28: 1484–1495 (1956).
19. Lawrence, W. A. and Sakamoto, W., *Tappi* 42, No. 1: 93–96 (1959).
20. Miller, L. P., *Contrib. Boyce Thompson Inst.* 16: 73–83 (1950).
21. Postgate, J. R., *Ann. Rev. Microbiol.* 13: 505–520 (1959).
22. Postgate, J., "Progress in Microbiology," 2: 49–69, N. Y., Interscience, (1960).
23. Postgate, J. R., Butlin, K. R., Thomas, S. L. S., and Senez, J. C., *Chem. & Ind.* (Lond.), 539–540 (1954).
24. Prince, H. N., *Nature* (Lond.) 186: 816–818 (1960).
25. Starkey, R. L., *Ind. Eng. Chem.* 48: 1429–1437 (1956).
26. Starkey, R. L., "Sulfate-Reducing Bacteria: Physiology and Practical Significance," Bull. Univ. Md., Dept. Microbiology, College Park, Md., 1960/61.
27. Starkey, R. L. and Wight, K. M., "Anaerobic Corrosion of Iron in Soil," Amer. Gas Assoc. Tech. Rpt., Distribution Comm., New York, 1945.
28. Subba-Rao, M. S., "A biochemical study of the microbiological formation of elemental sulfur in coastal areas," Dissertation, Bangalore, 1951.
29. Wilson, J. N., *Sewage and Ind. Wastes* 25: 1210–1218 (1953).

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Basic Data for Dilute Fiber Suspensions in Uniform Flow with Shear

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This article is one of a series describing the results of TAPPI sponsored research on the flow characteristics of dilute fiber suspensions. The research objective is the investigation of the internal flow mechanics of different suspensions under laminar and turbulent shear and in relation to flow in paper machines. Three wood pulp and two synthetic fibers having a wide range of physical characteristics were employed in experimental determination of flow resistance, velocity distributions and turbulence as functions of concentration and flow rate. The present article presents and compares basic data on flow resistance and velocity distributions and comments generally on the mechanics of flow with suspensions. It is observed that: wood pulp and nylon fiber suspensions behave in a similar manner in departing from Newtonian flow; with increasing length-to-diameter ratio and flexibility there are increasing departures from Newtonian behavior; at low velocities the results are consistent with the clear-water annulus concept; at high velocities the combined roles of turbulence and fiber entanglement govern the flow mechanics and departure from Newtonian behavior; with further increase in velocity and turbulence the behavior tends towards Newtonian.

In 1956 a research program on the flow characteristics of dilute fiber suspensions was initiated at the M.I.T. Hydrodynamics Laboratory under the sponsorship of the TAPPI Fluid Mechanics Committee. This was established as part of the program toward a better understanding of the causes of nonuniformity in the paper sheet and was directed particularly toward the effects of flow in the components of the paper machine ahead of the fourdrinier wire.

A preliminary examination of the broad aspects of the problem (*26*) emphasized the need for a more thorough understanding of the basic mechanics of flow of suspensions. In paper machines, shear flows predominate and occur both as uniform and as nonuniform motions. It was recognized that simple shear flows with uniform motion in circular tubes would yield more extensive information and could be studied more conveniently than other cases. Moreover, the information and conclusions would transcend the application to tubes and allow inferences of a general nature to be used in understanding dilute suspension flows confined by different boundaries and having different overall characteristics. Accordingly, a series of experiments were made investigating the internal flow mechanics of different suspensions in tubes, and the results analyzed in terms of their bearing on flow in paper machines.

These experiments have included qualitative observations of flow details and quantitative measurements of velocity distributions and, for the first time, turbulence, all with a variety of fibers at various concentrations. They also included measurements of flow resistance and boundary shear for flow rates ranging from very low velocities up into the turbulent-flow range. There resulted a unique set of experimental data combining in one systematic test series comparative results for all of the above. The results and conclusions have been submitted to TAPPI in a series of comprehensive reports (*12a–12d*) To make the information more generally available this and subsequent articles will summarize the findings.

The first article will be devoted to presenting the experimental procedures and results for flow resistance and velocity distributions. These results form a set of basic data of broad general usefulness. A second article will review and discuss the mechanics of laminar flow and the transition to turbulence and will compare rheological models and rheological characteristics of suspensions with actual behavior under shear. A third article will present the results of turbulence measurements and will analyze the mechanics of turbulent flow. The conclusions and implications of the entire set of experiments as regards the flow in papermaking machines will be discussed.

NOMENCLATURE

c	= subscript denoting critical conditions
C	= concentration, % (weight)
d	= peripheral annulus thickness, ft.
D	= tube diameter, ft.
E	= modulus of elasticity, p.s.i.
f	= friction factor
f_c	= value of the friction factor at the end of the laminar regime
g	= gravitational acceleration (32.2 ft./sec./sec.)
ΔH	= head loss, ft. of water
L	= lengths of pipe over which a given pressure drop, ΔP, occurs, ft.; also fiber length, mm.
ΔP	= pressure drop, lb./sq. ft.
Q	= discharge, cu. ft./sec.
r	= radial distance
R	= pipe radius
R_f	= radius of flat velocity region in velocity diagrams (Figs. 21–23) } ft. or in.
R_p	= possible plug radius
$\mathbf{R}$	= Reynolds number in general, Newtonian Reynolds number for flow in circular pipe
$\mathbf{R}_d$	= annulus Reynolds number
$\mathbf{R}_{L'}$	= generalized Reynolds number correlating f for the laminar range, [e.g., ref. (*35*)]
t	= time, sec.
t_D	= motion decay time, sec.
u	= local mean velocity, f.p.s.
U_M	= mean velocity at the centerline, f.p.s.

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The TAPPI sponsored work has provided thesis material for three graduate students: G. Bugliarello, Sc.D., 1959; W. W. Troutman, S.M., 1958; and A. Tsuchiya, S.M., 1959. Portions of the material in this paper appeared in these theses.

U_P = plug velocity, f.p.s.
V = average bulk velocity (discharge/area of cross-section), f.p.s.
w = subscript denoting conditions at the wall
W = fiber width, microns or mm.
x = distance in the axial direction (mean flow direction), ft.
y = distance from the wall, ft. or in.
γ = specific weight, lb./cu. ft.
μ = molecular dynamic viscosity for Newtonian fluids
$\mu_{effective}$ = effective viscosity for non-Newtonian fluids
} lb. sec./sq. ft.
ν = Newtonian molecular kinematic viscosity ($= \mu/\rho$), sq. ft./sec.
ρ = fluid density, mass (slugs)/cu. ft.
τ = local shear stress
τ_s = shear stress at the surface of the plug
τ_w = wall shear stress
τ_y = yield shear stress
} lb./sq. ft.

REVIEW OF LITERATURE

Important literature relative to the M.I.T. investigations of dilute fiber suspensions includes flow of fiber suspensions themselves, flow of other suspensions and of related fluids and the rheological behaviors and theories of non-Newtonian fluids. The bibliography covers these topics and includes pertinent references on turbulence and measuring techniques as well. The following is a brief review of some of the more important references on earlier experiments with suspensions and related fluids. The literature on rheology and on turbulence as it applies to suspensions will be reviewed in detail in later articles.

Flow Resistance

Table I compares the range of variables and test conditions for the more significant work on flow resistance in pipes. In the table the terms laminar, transition and turbulent refer respectively to flow regimes associated with very low velocities (plug flow), intermediate velocities (disintegration of plug flow) and high velocities (with effective turbulent mixing). Smooth pipes include glass, lucite, and copper. Rough pipes include steel and cast iron, except for Baines who used a tube with corrugated walls. The kinds of correlations presented by the several authors are in terms of symbols defined in the Nomenclature.

It will be noted that only Brecht and Heller (*9*), Baines (*3*), Robertson and Mason (*45*), and Guthrie (*20*) have investigated suspensions at concentrations lower than 1.0%. We also note that only Baines reports on experiments in vertical pipes. Of the experiments in the same range of concentrations as the present ones, only those by Mason, *et al.*, Baines, and Guthrie were conducted in pipes of approximately the same diameter as the present setup. Finally, there is a wide variety in the types of fibers used, and even fibers of the same type cannot be expected to be identical because of differences in origin and in treatment during the pulping process. Thus, exact agreement cannot be expected, nor was it obtained, between the various experimental results.

In general, the difficulties in predicting theoretically the flow characteristics of fiber suspensions have led to the common approach of concentrating at first on the collection of experimental data for as wide a range of conditions as possible. Typical are the studies of Brecht and Heller (*9*), and Durst and Jenness (*14*). Successively—and this is the current stage of the art—experimental investigations have been coupled with theoretical interpretations (but only for the low flow rates). Thus, while earlier investigators have limited themselves to presenting the results in the form of pressure drops or friction factors versus velocity (the non-Newtonian character of the suspensions, and hence the impossibility of using a conventional Reynolds number, having soon been recognized), in recent publications more complex correlations have been introduced which interpret the laminar flow regime in terms of some significant physical characteristic of the suspensions. A pioneering work in this respect was that of Van den Akker and associates who used viscometer measurements of the yield shear stress of the suspensions and of their friction against a solid boundary to explain the several regimes observed in pipe flow. This was followed by the published works of Head (*21*), and Durst and Jenness (*14*), correlating the flow behavior in pipes with a yield shear stress of the suspensions. A particularly satisfactory determination of the shear stresses and a critical review of the pertinent literature is contained in an unpublished thesis by Richardson (*41*). The consideration of a yield stress as a determining factor in the flow of the suspensions leads to a description of the flow as consisting of a central unstrained core (corresponding to the portion of the cross-section where $\tau < \tau_y$), surrounded by a strained annulus (for the portion of the cross-section where $\tau > \tau_y$). The friction losses are determined by the velocity profile and viscous characteristics of the fluid in the annulus. At the low flow rates for which the shear stress at the wall, τ_w, is lower than the yield stress, another flow regime must be present. Thus Gray and Van den Akker (*18*) have proposed that at such flow rates the whole cross-section moves as a plug and the slip at the boundary determines the head loss of the flow.

Another significant rheological characteristic is the tensile stress of fiber networks, determined by Forgacs, Robertson, and Mason (*15*), who also have analyzed the flow in terms of a central plug, surrounded by a peripheral strained annulus, and have proposed that a change in the slope of a head loss versus discharge curves occurs when the flow in the annulus reaches a critical Reynolds number.

Robertson and Mason (*43*) have also observed that there is a correlation between friction factor and degree of flocculation of the flow (determined through optical transparency measurements), a high value of the friction factor corresponding to a high degree of flocculation.

Recently Baines (*4*) has correlated friction loss data on the basis of the shear stress acting on the surface of the plug (surface stress τ_s), a parameter of not very clear rheological interpretation. For a given fiber and concentration the stress is shown to be a function of the wall stress only; hence the peripheral annulus dimensions are also uniquely determined from the wall shear stress, irrespective of pipe size.

Far more complex than the laminar regime are the turbulent regime and the transitional regime from laminar conditions. For the fiber suspensions the difficulty in understanding the basic mechanism of turbulent flow is heightened by the severe instrumentation problems involved in measuring velocity and turbulence. Thus, as shown in Table I, whereas several

turbulent friction-loss measurements are reported in the literature, the interpretation of the results has been until now almost exclusively a matter of conjecture. The lower head losses observed in smooth pipes for the turbulent flow of supensions as compared to those for water were intuitively attributed to a modification of the scales and intensities of turbulence (*39*, *53*), but there were no measurements available to confirm such hypotheses.

Velocity and Turbulence Measurements

The main practical instrumentation problem encountered in the measurement of local velocities in the suspensions is due to the tendency of the fibers to cling to any sharp-edged surface. This makes it difficult to use impact tubes of conventional design as reported, e.g., by Baines (*3*), and must account for the fact that only one set of velocity measurements is reported in the literatures, that by Brecht and Heller (*9*), who used a large-sized countercurrent pitot tube in a 5.9-in. copper pipe. The published measurements were limited to the higher flow rates (>7.0 ft. per sec.). Robertson and Mason (*44*) succeeded in sketching velocity profiles from high-speed photographs, but admittedly the results were mere qualitative "impressions."

There are no turbulence measurements in fiber suspensions reported in the literature. Indirect evidence of the effect of turbulence is shown by Moss and Bryant (*37*), who have taken photographs of fiber motions in very dilute fiber suspensions from 0.001 to 0.25% concentrations (*10*, *37*, *38*), and by Mason and co-workers (*32*), who have studied the lateral distribution patterns of fibers moving down the wire of a fourdrinier machine and diffusing from a continuous point source at the slice.

Table I. Summary of Principal Investigations of Flow Resistance in Circular Pipes

Author	Reference	Year	Fiber	S.-R. freeness, cc.	Concn., %	Pipe size (I.D.), in.	Pipe roughness	Pipe layout	Flow regime	Correlations
1. Forrest and Grierson	*48*, *16*	1931	Unbleached free, sulfite, groundwood		1–5.8	6, 8, 10, 12	Rough	Horiz.	Laminar and turbulent	ΔH vs. V
2. Brecht and Heller	*9*	1934	Unbleached sulfite	822	0.50–5.0	5.90, 7.87, 9.84	Smooth and rough	Horiz.	Laminar and occasionally turbulent	ΔH vs. V
			Bleached sulfite	780						
			Unbleached sulfate	860						
			Bleached straw	500						
			Groundwood	280						
			Cooked groundwood	480						
			Unbleached straw	800						
3. Nilson	*39*	1944	Bleached sulfate Unbleached sulfate	830–380	0.98–4.05	3.95	Smooth	Horiz.	Laminar and turbulent	ΔH vs. V
4. Guenther and Ceaglske	*19*	1951	Unbleached sulfite		1.16 2.73	1.0	Smooth	Horiz.	Laminar and transition	ΔH vs. V; $\mu_{effective}$ vs. V
5. Durst and Jenness	*14*	1954	Bleached sulfite	650	2.0–6.0	6.34	Rough	Horiz.	Laminar and turbulent	ΔH vs. V; Shear value S vs. V; vs. $\frac{VD}{S}$
		1955	Bleached soda Unbleached kraft Unbleached groundwood							
		1956	Unbleached sulfite			8 and 12				
6. Richardson	*41*	1954	Bleached		1.0–3.6	1½, 2, 3, 4	Rough	Horiz.	Laminar and transition	f vs. $\frac{V^2}{\tau_y}$
7. Baines	*3*, *4*	1956 and 1958	Sulfite		0.25–1.0	2.0	Smooth and rough	Horiz. and vert.	Laminar and turbulent	vs. $\frac{VD}{\nu_{water}}$ τ_s vs. concn.
8. Mason, Robertson, Forgacs	*15*, *42*, *43*, *45*	1956 1957 1958	Rayon, 1.5 mm. Groundwood Fir sulfite Softwood Sulfite Softwood kraft	318–740	0.013–1.0	⅞	Smooth	Horiz.	Laminar and turbulent	Floccul. ind. vs. V; ΔH vs. V; vs. V
9. Guthrie	*20*	1958	Bleached kraft Bleached sulfite	410–670 390–375	0.43–1.95	½, 1	Smooth	Horiz.	Laminar and turbulent	f vs. R_L'

Table II. Principal Fiber Characteristics

Fiber	Kraft softwood (Long Lac 17)	Kraft softwood (Coosa River 55)	Groundwood	Synthetic	Synthetic
Composition	65% Spruce 35% jack pine	Southern pine	Poplar	Nylon	Nylon
Designation	LL 17	Cr 55	GW	N3d	N1.5d
Fiber width,[a] microns	43	47	40	19.4 (3 denier)	13.75 (1.5 denier)
Fiber length,[a] mm.	2.52 (0.099″)	2.61 (0.102″)	0.49 (0.019″)	6.47 (0.25″)	5.07 (0.20″)
Length-to-width ratio	58.5	55.5	12.2	334	369
Initial modulus (E), p.s.i. (wet)				219,000	219,000
Relative flexibility (Rel to GW)	$102\frac{E_{GW}}{E_{LL}}$	$80\frac{E_{GW}}{E_{CR}}$	1	$42{,}000\frac{E_{GW}}{E_{N3d}}$	$79{,}000\frac{E_{GW}}{E_{N1.5d}}$
Hydrodynamic specific surface, sq. cm./cc.	9900	8200	22,000	2100	2700
Hydrodynamic specific volume, cc./g.	1.28	1.29	2.06	0.876	0.876
Millions of fibers per gram of pulp	5.28	3.44	Very large	0.46	1.62
S.-R. freeness, cc.	870	885	500	900	
Ratio pipe diameter to fiber length:					
$^3/_4$″ pipe	7.56	7.3	38.8	2.94	3.75
2″ pipe	20.2	19.4	104	7.85	10

[a] Weighted average.

Flow of Related Fluids

There is a growing body of literature on the flow of non-Newtonian fluids other than fiber suspensions. Experimentally, as for fiber suspensions, most of the studies are concerned with rheological characteristics or with pipe friction. With regard to the latter, it is interesting to note that in some cases adding a component with long molecules to a liquid resulted in higher friction losses at low flow rates and lower friction losses at high flow rates (*1, 47*). This is analogous to the behavior observed in fiber suspensions in smooth pipes.

Recently, velocity profiles in solutions exhibiting the above characteristics were obtained by Shaver with a small-size impact tube in a circular pipe (*47*). At the higher flow rates the profiles were found to be sharper than for a corresponding Newtonian flow, and hence the momentum exchange coefficients lower. This did not check Dodge and Metzner's (*13*) prediction of blunter-than-Newtonian profiles; the disagreement was attributed by Dodge and Metzner to the possible presence of elastic effects in the fluids used by Shaver (*47*).

Sediment-carrying flows, although not necessarily non-Newtonian in character, can also offer some insight into the interactions of suspended matter and a Newtonian suspending phase. Values of the momentum exchange coefficients lower than the corresponding Newtonian ones have been reported for such flows (*27, 54*).

Both in the case of long-molecule solutions and of sediment suspensions, the lower momentum exchange coefficients resulting from velocity profile analyses were attributed to modifications of the turbulent scales. For neither case, however, are direct turbulence measurements given in the literature.

FIBER CHARACTERISTICS

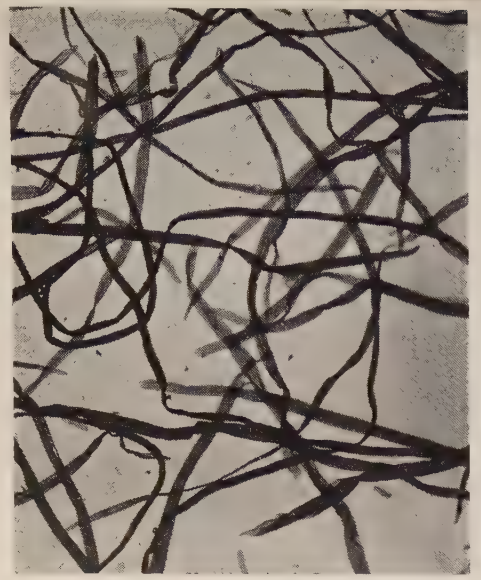
The present experiments were concerned with dilute solutions. The term dilute as used here refers to the range of concentrations up to approximately 1% by dry weight. This is the range of significance at the wet end of the papermaking machine, since it encompasses the concentration at which the fibers, suspended in water, are conveyed to the wire and led to form the paper sheet through drainage of the suspending phase. It is also the range over which a transition takes place from a condition in which the fibers are free to move without reciprocal interference to a condition in which they aggregate in strong and extended structures. Fortunately, it includes the range in which the interaction of fibers and suspending phase can more easily be observed and analyzed.

The M.I.T. test results described in the following are for three natural fibers and a synthetic fiber in two

Table III. Rank of Fibers by Properties

Length (L), mm.		*Width (W), mm.*		L/W		*Hydrodynamic specific surface, sq. cm./cc.*		*Hydrodynamic specific volume, cc./g.*	
GW	0.49	N1.5d	0.014	GW	12.2	N3d	2,100	N1.5d	0.876
LL 17	2.52	N3d	0.019	CR 55	55.5	N1.5d	2,700	N3d	0.876
CR 55	2.61	GW	0.040	LL 17	58.5	CR 55	8,200	LL 17	1.28
N1.5d	5.07	LL 17	0.043	N3d	324	LL 17	9,900	CR 55	1.29
N3d	6.47	CR 55	0.047	N1.5d	369	GW	22,000	GW	2.06

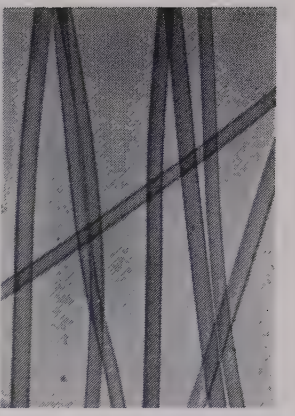
Fiber count, millions/g.		*Pad density, g./cc.*	*S.-R. freeness, cc.*		*Relative flexibility $\times E/E_{GW}$*	
N3d	0.46	GW	GW	500	GW	1
N1.5d	1.62	LL 17	LL 17	870	CR 55	80
CR 55	3.44	CR 55	CR 55	885	LL 17	102
LL 17	5.28		N3d	900	N3d	42,000
GW	Very large				N1.5d	79,000



Long Lac 17. Magnification 35×

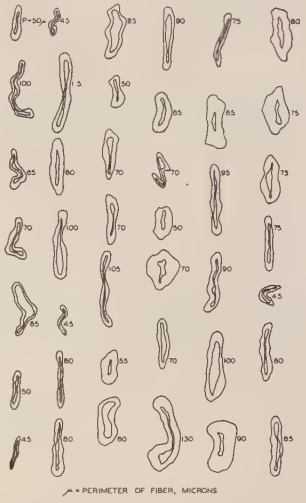
Coosa River 55. Magnification 35×

Poplar Groundwood. Magnification 35×

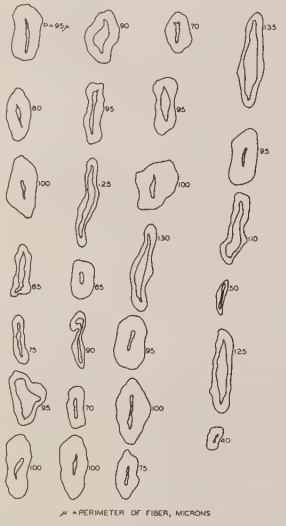


Nylon: 3 denier. Magnification 110×

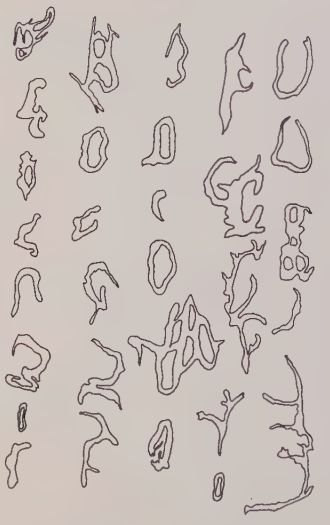
Fig. 1. Photomicrographs of fibers



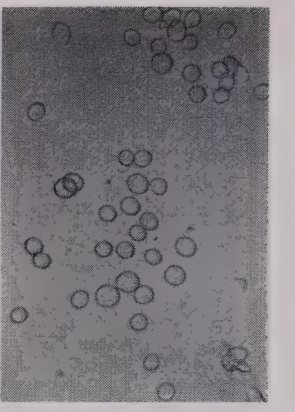
Long Lac 17. Magnification 210×



Coosa River 55. Magnification 210×



Poplar Groundwood. Magnification 210×



Nylon: 3 denier. Magnification 110×

Fig. 2. Cross-sections of fibers

sizes. Tables II and III give the characteristics of the fibers. Photomicrographs and drawings of cross-sections are shown in Figs. 1 and 2. The three natural fibers and a 3-denier nylon were supplied by the Kimberly-Clark Fluid Mechanics Laboratory, Neenah, Wis. The data in Tables I and II for these were determined by the Institute of Paper Chemistry, Appleton, Wis. (*23*). A 1.5-denier nylon was supplied by the Du Pont Pioneering Research Laboratory, Wilmington, Del. The natural fibers came in the form of dry-pressed sheets of pulp, requiring only soaking and fiberizing with a propeller mixer prior to testing. The synthetic fibers, as supplied, were of uniform length.

The three natural fibers were selected as relatively stable and covering a range of length, flexibility, etc. Among the many synthetic fibers nylon was selected because its density is near that of water, it absorbs water to only a slight degree (7% at 90% R.H.) and it has a circular cross-section. Thus, it represents a simple basic geometry described by a limited number of parameters in contrast to any of the natural fibers. The 1.5-denier nylon was supplied in a variety of lengths. However, it was not possible to complete the test series planned originally and for reasons explained later, data to be included here will be only for the length shown in the table.

Consider now the rankings by property in Table III. The fiber length-to-width ratio is a measure of the tendency to interlock and form networks. Another measure is the flexibility which is proportional to:

$$\text{Flexibility} \propto \frac{L^3}{W^4 E} \qquad (1)$$

Relative values depend on the ratio of the elastic modulus E which is unknown for the wood pulps. Nevertheless, the order of increasing flexibility is readily apparent and agrees with L/W ranking. Still another measure of the character of the network is the pad density resulting from a given compacting pressure. Again the rank is the same. The lower density for groundwood is attributed to the large number of short inflexible fibers per unit volume. Long Lac 17 has a higher number of fibers per unit volume than Coosa River, so its pads have slightly lower density. Both Long Lac 17 and Coosa River give densities increasing with pressure at a higher rate than for groundwood. This seems due to greater flexibility and ability of the fibers to slip into more compact configurations. Hydrodynamic specific surface gives the external surface area of fibers and fines that offer resistance to flow through fixed fiber beds. Hydrodynamic specific volume is the volume denied to fluid flow in a porous bed (per unit mass of fibers on a dry basis). Freeness is a measure of the rate at which a dilute suspension may be partially dewatered. The values shown were obtained in a Schopper-Riegler tester (*48*). It is seen that groundwood, which has the largest number of fibers per unit weight and the most irregular cross-section, offers the greatest resistance to drainage. From the above, it can be concluded that:

1. Long Lac 17 and Coosa River 55 have similar characteristics.

2. Groundwood has the smallest fiber dimensions, the shortest length-to-width ratio, the smallest fiber pad density and pad compressibility. As a consequence

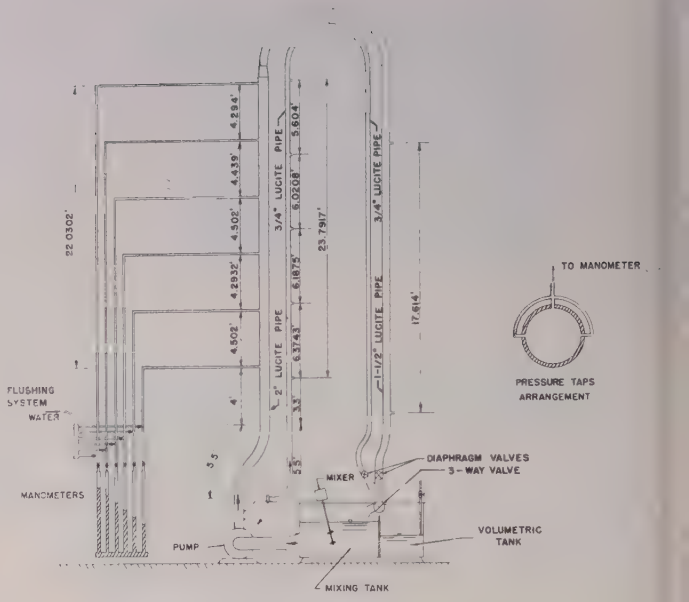


Fig. 3. Experimental setup of vertical loops

of the three last characteristics, it can be expected to aggregate in flocs less easily than the other two fibers, and to form less flexible and weaker fiber networks.

3. Groundwood has the largest surface area of the fibers, the most irregular fiber contour configuration and the largest number of fibers per unit volume. Thus, hydrodynamic drag phenomena on the fiber surfaces can be expected to be stronger for groundwood.

4. The highest pipe-diameter to fiber-length ratio is for groundwood in the 2-in. pipe; the lowest is for nylon in the $^3/_4$-in. pipe. Any pipe size effects might be expected to be more marked for the lowest ratios.

EXPERIMENTAL APPARATUS AND PROCEDURES

Flow Resistance Experiments

The flow-resistance measurements were conducted in vertical loops to avoid asymmetries in the consistency of the suspensions across the diameter, which would occur with a horizontal setting at low flow velocities. The equipment consisted of transparent smooth tubing arranged in two loops, as shown schematically in Fig. 3. The legs of one loop were 2 in. and $1^1/_2$ in. in I.D., respectively; the other loop had two $^3/_4$-in. I.D. legs. The material was Lucite, except for an 8 ft. precision-bore glass observation section at the lower end of one leg of the $^3/_4$-in. loop.

The suspensions were circulated from a stock tank by means of an open-impeller centrifugal pump, coupled to a d.c. motor with Ward-Lennard system controls. Flow rates could be attained by speed regulation and

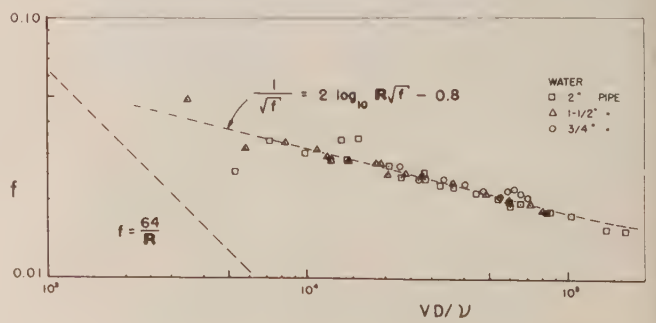


Fig. 4. Friction factor vs. Reynolds number with water

Fig. 5. Impact probe tips

by throttling with diaphragm valves at the ends of the loops. The direction of flow in the loops could be reversed by switching their upstream and downstream connections.

The stock tank was divided into two unequal compartments by a vertical baffle. The smaller compartment served as volumetric measuring tank calibrated by adding known weights of water. The larger one served as head tank and mixing tank from which the suspensions were pumped into the loops. Throughout the tests, a simple two-propeller mixer continuously agitated the suspension.

The flow from the downstream end of the loops converged into a three-way, 2 in. full port plug valve, allowing practically instantaneous switching of the flow from mixing tank to measuring tank, and vice versa. In order to reduce aeration of the suspensions, the discharge into both tanks was submerged by the use of two equal flexible hoses connected to the two outlets of the three-way valve. On diversion of flow into the measuring tank the level in the mixing tank dropped slowly. The resulting lower positive pressure at the pump suction caused a slight reduction in flow rate through the loop so that an average value was measured during the diversion interval. The maximum reduction was about $1^1/_2\%$ (giving an average reduction of about 0.75%) and occurred only for the highest discharges, when use of the entire volume of the measuring tank was necessary.

Pressures along the loop were measured by means of a multiple-tube, common-reservoir manometer board connected to pressure taps located at several stations on each leg of the loop. At each station three pressure taps arranged peripherally as shown in Fig. 3 were interconnected, and the resulting average pressure was measured. To prevent clogging of the pressure taps by stock fibers, a clear water back-flushing system was provided. Two manometric fluids were used mercury for the higher velocity tests, and a liquid of

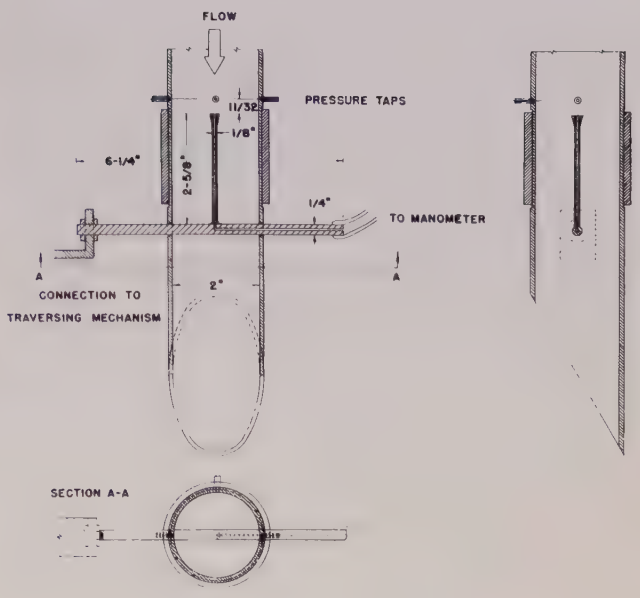


Fig. 6. Velocity probe setup

specific gravity 1.75 for tests at lower velocities.

The flow resistance data described in this article were obtained in the risers of the two loops (e.g., in upward flow conditions), between the two extreme pressure-tap locations shown. This gave a test section of 22.03 ft. for the 2-in. pipe and 23.79 ft. for the $^3/_4$-in. pipe. Following a mild double bend connection of approximately 5.5 ft. from the pump discharge, the length of straight pipe ahead of the first pressure tap was 4 ft. for the 2-in. pipe (24 diameters) and 3.3 ft. for the $^3/_4$-in. pipe (52.7 diameters).

The inlet length required for the establishment of uniform flow conditions has been reported in the literature (*41*) to be lower for pulp suspensions than for water. Its adequacy in the present setup, both with the suspensions and with water, was checked by comparing the f values taken between the two extreme stations with those resulting from measurements taken at intermediate stations. Some variation in the f values, equation (2), were found, but they were random along the pipe length.

The friction factors

$$f = \frac{\Delta P}{\frac{L}{D}\frac{V^2}{2g}\gamma} \qquad (2)$$

obtained with water in the two loops are shown in Fig. 4. The experimental points (which cover the flow ranges of the tests with suspensions) agree with the established results for smooth pipes (dashed lines). Measurement accuracy is lowest at low flow rates where

Table IV. Flow-Resistance Tests

Fiber	*Kraft softwood (Long Lac 17) LL 17*	*Kraft softwood (Coosa River 55) CR 55*	*Poplar groundwood GW*	*Nylon N3d*	*Nylon N1.5d*
$^3/_4$" Pipe tests, %	0.10	0.10	0.10	0.10	0.10
	0.25	0.25	0.25	0.25	0.25
	0.50	0.50	0.50	0.50	0.50
	0.75	..	0.75	..	..
	1.00	1.00	1.00	..	..
2" Pipe tests, %	0.10	0.10	0.10	..	0.10
	0.25	0.25	0.25	..	0.25
	0.50	0.50	0.50	..	0.50
	0.75	0.75	0.75	..	..
	1.00	1.00	1.00	..	..

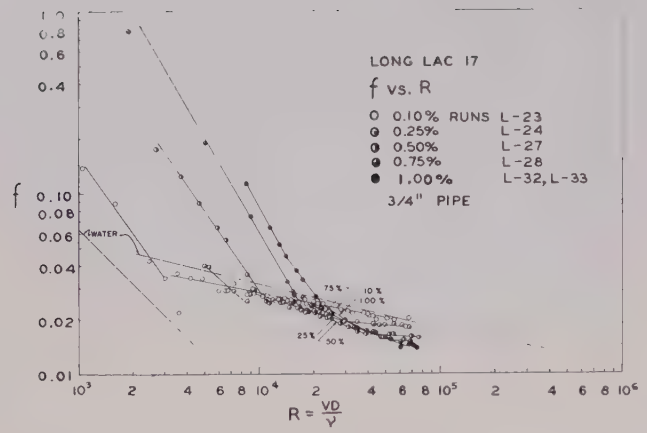


Fig. 7. Friction factor vs. Reynolds number: LL 17, 3/4-in. tube

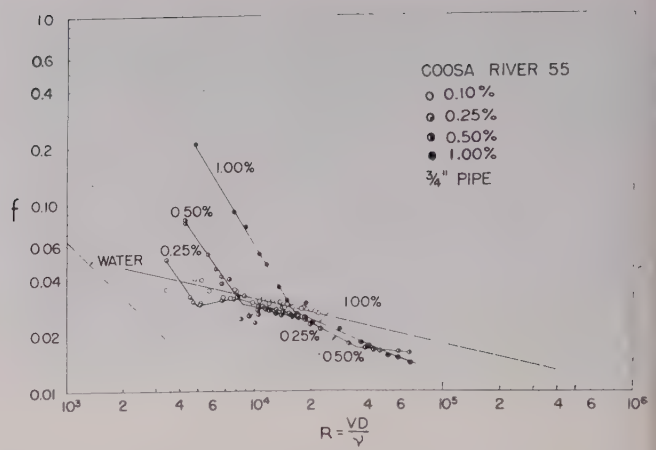


Fig. 9. Friction factor vs. Reynolds number: CR 55, 3/4-in. tube

pressure differentials are small, as shown by the scatter in the water tests. With suspensions the formation of plug flow results in high resistance at these same low flow rates and increases the measurement accuracy.

A typical run with the suspensions consisted of approximately 20 to 40 pressure-drop measurements and was performed by starting with a flow rate correspondind to one end of the range of pressure drops, which could be covered with a given manometric fluid, and then progressing toward the other end of the range. When such end was reached the flow was varied in the opposite direction, in order to obtain a check. After checking, the pressure lines were connected to the manometer columns filled with the other manometric fluid. The two ranges of pressure drops measured with the two different manometer fluids always overlapped. Particular care was taken to check the regions where the lines connecting the experimental points changed slope.

Velocity Traverses

The velocity and turbulence traverses were made in a horizontal loop because it simplified the installation and operation of the probing instruments which were similar for the two kinds of measurements. The test flow rates were high enough to assure strong turbulent activity and minimize asymmetries in consistency (and hence velocity and turbulence) across the vertical diameter. The loop consisted of two horizontal straight legs, each approximately 22 ft. long, connected by a 180° bend having a 2.5-ft. radius. One leg and the elbow were rubber hose of nominal 2-in. diameter; the other side was Lucite pipe of 2-in. I.D. Flow from the stock tank was circulated through the rubber hose leg into the Lucite test leg, from which it discharged as a jet back into the stock tank. Pressure taps were provided along the Lucite pipe and connected to the common-reservoir manometer board. The velocity and turbulence measurements were taken at the downstream open end of the Lucite leg. The probes were mounted on a horizontal traversing mechanism with micrometer screw adjustment. The traversing mechanism was supported by a vertical steel column, rubber-mounted on the concrete floor of the laboratory basement. Independent support of the probe was provided to minimize transmission of mechanical vibration to the pressure pickups used for turbulence measurements. With free discharge from the open-ended tube air entrainment required special attention at the highest velocities for the higher concentrations. Deflectors and baffles were used to help maintain satisfactory flow conditions.

The mean-velocity traverses were taken with an impact tube having a flat circular face. The blunt shape was found to be effective in preventing fiber clustering at the tip. The required tip size increases

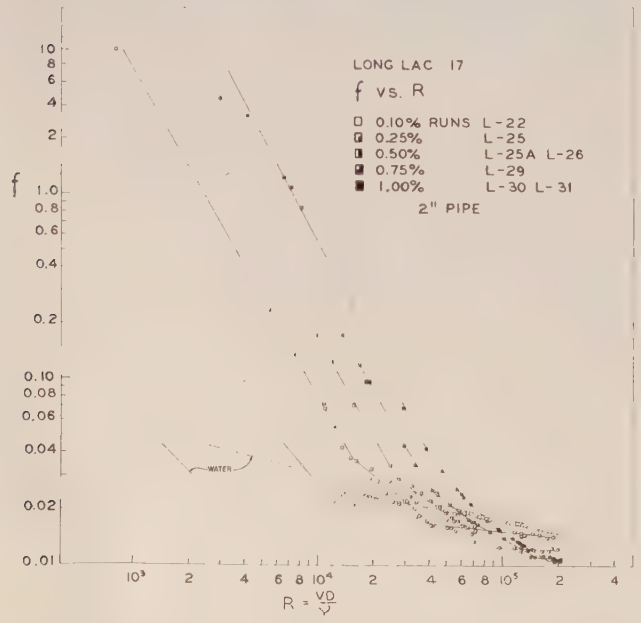


Fig. 8. Friction factor vs. Reynolds number: LL 17, 2-in. tube

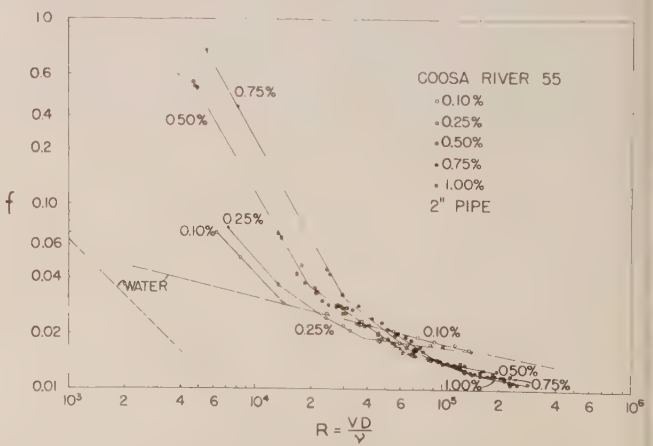


Fig. 10. Friction factor vs. Reynolds number: CR 55, 2-in. tube

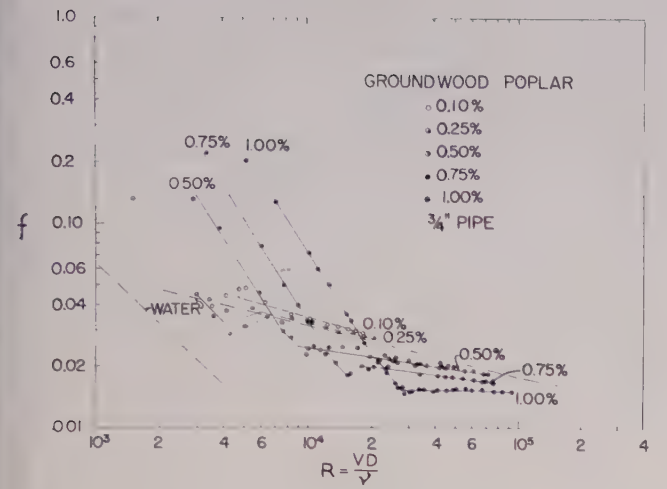


Fig. 11. Friction factor vs. Reynolds number: GW, ¾-in. tube

with increase in fiber length and concentration. Two sizes were used in the experiments. In some preliminary measurements one of 0.15-in. diameter was effective with Long Lac 17 for concentrations up to 0.5%; a second of 0.25-in. diameter could be used up to 1.0% and was adopted for the bulk of the measurements. The mushroom-shaped tip was attached to a ⅛-in. tube. The diameter of the pressure opening in either tip was approximately 1/32 in. In general, groundwood fibers are less prone to cluster at the probe tip than longer fiber stocks, but groundwood fines are apt to penetrate into the pressure opening of the probe. The latter difficulty was not encountered with other stocks. Provisions were made for back flushing the probes (as for the pipe wall pressure taps) in case of either difficulty.

Figures 5 and 6 show the two tips and details of the arrangement for traversing. As seen in Fig. 6 the T-bar probe unit was sandwiched between two halves of a Lucite extension to the loop. The extension both facilitated the mounting of the probe and insured a hydrostatic pressure distribution (and normal velocity distribution) in the plane traversed by the probe tip.

In measuring the velocity the total head at the probe tip was referred to the static pressure at the pipe wall, using an inverted U-tube air–water manometer. To minimize interference effects as the probe approached the wall, the static pressure was taken from a piezometer tap just upstream of the probe tip and corrected to the plane of the traverse. Nevertheless, because of the relatively large tip size, measurements very near the pipe wall are considered to be less accurate than those in the central region. With fibers, clustering would occur whenever the tip touched the wall, thus restricting the extent of a traverse.

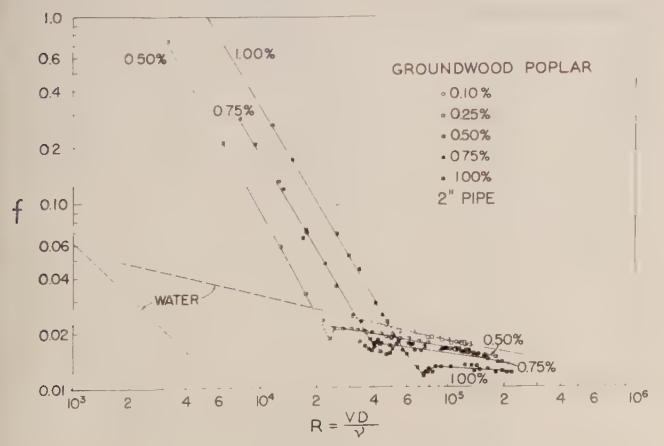


Fig. 12. Friction factor vs. Reynolds number: GW, 2-in. tube

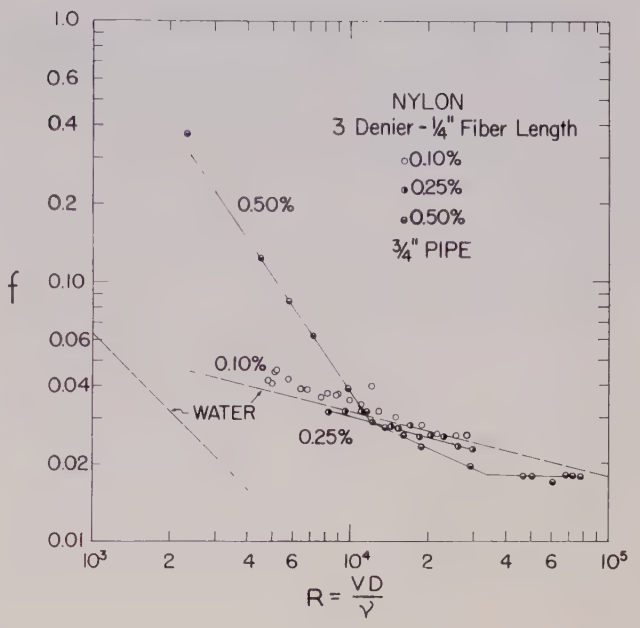


Fig. 13. Friction factor vs. Reynolds number: N3d, ¾-in. tube

RESULTS

Flow Resistance Data

The results described here include flow resistance measurements in ¾- and 2-in. diameter tubes for the three natural fibers and the synthetic fibers listed in Table II. Flow rates ranged from velocities near zero to approximately 12 ft. per sec. in both tubes. Test combinations for which data are given are shown in Table IV.

The experimental results are presented in two different forms. Figures 7 to 15 show for all the fibers the friction factor f versus Reynolds number. The friction factor is obtained from the relation:

$$h_f = f \frac{L}{D} \frac{V^2}{2g} \qquad (3)$$

Figures 16 to 18 show the data for the three natural

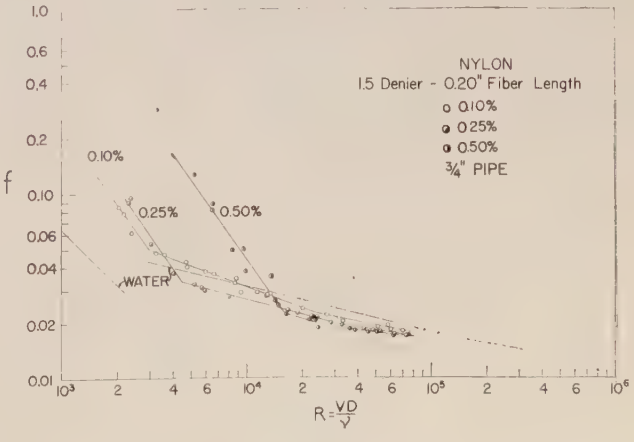


Fig. 14. Friction factor vs. Reynolds number: N1.5d, ¾-in. tube

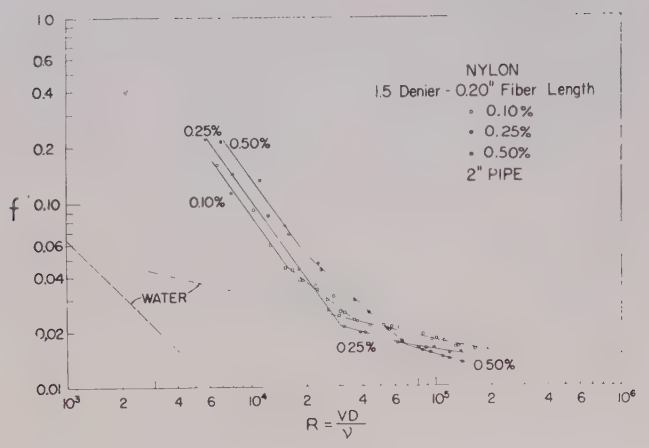


Fig. 15. Friction factor vs. Reynolds number: N1.5d, 2-in. tube

fibers as diagrams of wall shear stress τ_w versus $8V/D$. For Newtonian fluids in laminar flow the gradient du/dy at the wall is $8V/D$ so that:

$$\tau_w = \mu \left(\frac{du}{dy}\right)_w = \mu \frac{8V}{D} \qquad (4)$$

The figures also show curves describing the laminar and turbulent flow of water. The Reynolds number in Figs. 7 to 15 is arbitrary and is defined by equation (5):

$$\mathbf{R} = \frac{VD}{\nu} \qquad (5)$$

where ν is the kinematic viscosity of water at the temperature of the suspension.

These figures are converted readily to f versus velocity by dividing the abscissa by D/ν. For a temperature of 72°F. D/ν equals 6.25×10^3 and 1.67×10^4 for the 3/4- and 2-in. tubes respectively. On an f versus **R** diagram a single pair of lines for laminar and turbulent flow will describe all Newtonian flows for any pipe size, making for a more general comparison of suspensions and Newtonian behaviors. It readily shows, for a given fiber, pipe size and average velocity, how f is affected by fiber additions. Comparison of

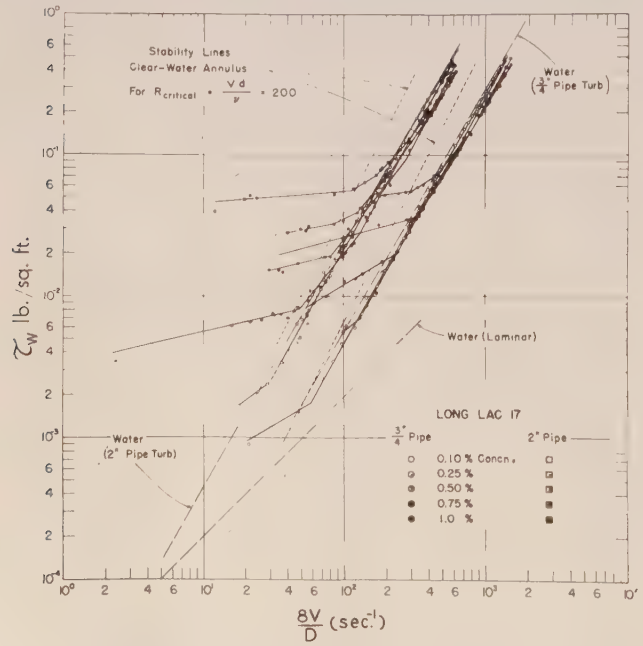


Fig. 16. Log-log flow diagrams: LL 17

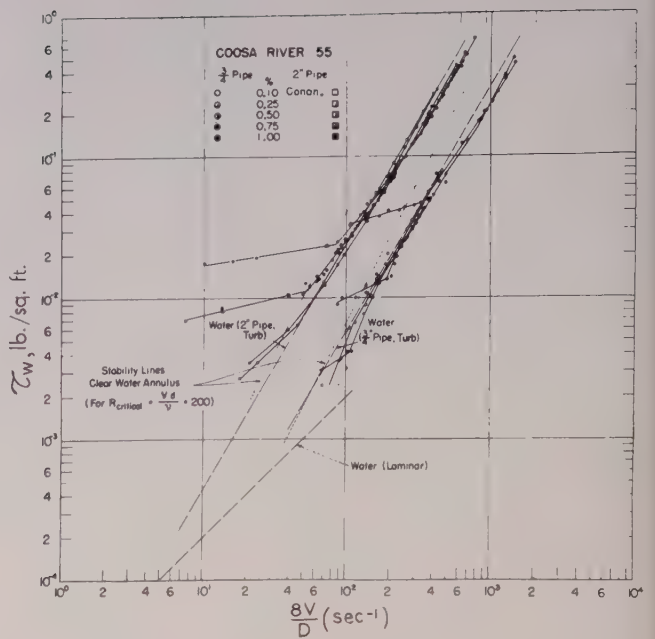


Fig. 17. Log-log flow diagrams: CR 55

diagrams for different fiber types and pipe sizes shows the influence of these two factors.

It will be noted that the nylon data are limited to concentrations of 0.5% or less. Originally it was planned to include higher concentrations and several additional fiber lengths. However, difficulty was encountered in keeping the synthetic fibers dispersed throughout the suspension and in avoiding foaming and air entrainment in the mixing tank. During initial experiments this was a special problem. By improving mixing arrangements and using dispersing agents and anti-foaming chemicals, satisfactory conditions were produced at low concentrations; but above 0.5% the difficulties remained. As a result the experiments became increasingly more time-consuming, limiting in turn the amount of data obtainable. In preparing the present paper all the data obtained [and previously presented in Refs. (*12a*) and (*12c*)] were reviewed and only the most reliable selected for inclusion here.

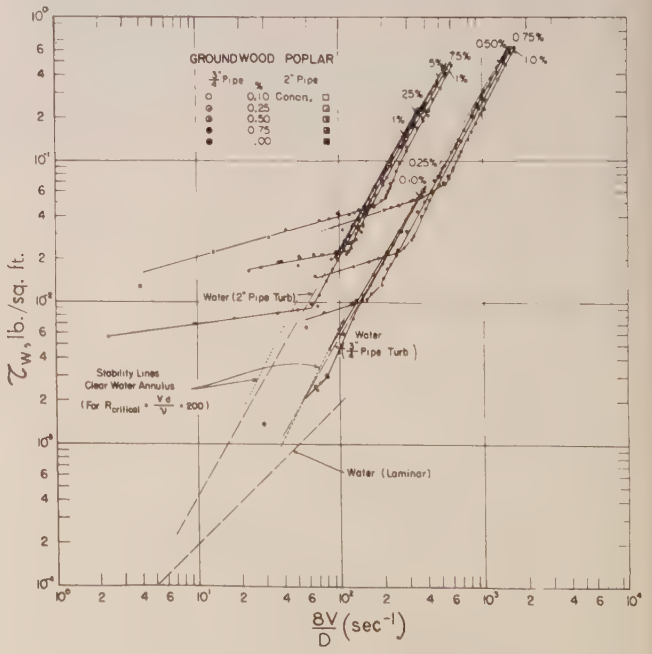


Fig. 18. Log-log flow diagrams: GW

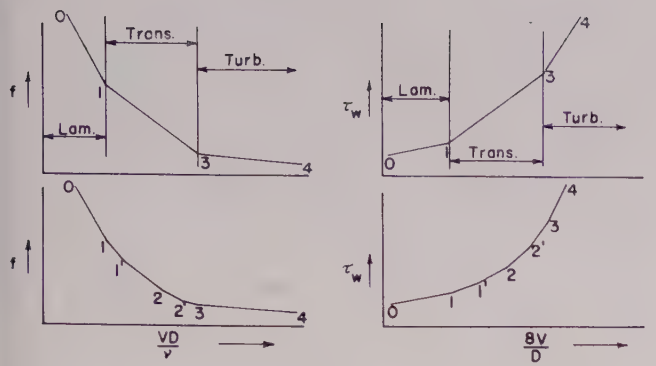


Fig. 19. Definition diagrams—regimes of flow

Laminar, Transition, and Turbulent Regimes

The flow-resistance data show some general facts which are described conveniently with the aid of the f versus R and τ_w versus $8V/D$ diagrams. These facts, which are well known for natural pulps (*3, 15, 41*), also hold for the inert synthetic fibers. Considering the f versus R diagrams first:

1. For a given fiber and pipe size, as concentration increases, the value of f differs increasingly from that for water at the same rate of flow. At the lower rates of flow it becomes higher, and at the higher rates it becomes lower than f(water). For the same fiber and concentration, the deviation from the f values for water is greater for flow in the larger pipe, particularly at low flow rates.

2. Close examination of the f versus Reynolds number diagrams shows separate zones or regimes over which the slope of the f curves is nearly constant.

3. While in general a transition from one regime to another covers a range of Reynolds numbers, the approximate extent of each regime can be indicated by drawing a series of best-fit straight lines through the experimental points.

In Fig. 19 three main flow regimes have been indicated by the regions *0–1*, *1–3* and *3–4*. These are termed laminar, transition, and turbulent, respectively; each corresponding to the hydrodynamic conditions of the zones within the conduit cross-section where shear flow exists. It is the behavior of these shear zones which determines the overall resistance characteristics of the flow.

In the *laminar regime* (region below *1*) the flow consists of a central core (the "plug"), practically unsheared, surrounded by a peripheral annulus, where the flow is laminar and the greatest part of the velocity variation from its zero value at the wall to its maximum value at the centerline takes place. In the *turbulent regime* (region *3–4*) the flow is considered as having reached a condition of turbulence throughout its cross-section (with certain limitations which will be discussed in a later article). In the *transition regime* (region *1–3*) turbulence sets-in in the annulus and as the flow rate increases, spreads to the entire cross-section.

Actually the regimes beyond the laminar represent a series of continuously changing conditions and the representation by straight lines only approximates the true relationships. For the transition regime particularly, a better representation may be given for some pulps by several lines rather than a single one. This is illustrated by the intermediate transition points *1′*, *2*, and *2′*, in Fig. 19. This description applies particularly to all the long fibers. In the case of groundwood the region *0–1* persists until the data show a sharp break to form the region *3–4*. The transition region is either absent or replaced by a short zone which shows some instability.

Finally, it must be recognized that a fourth regime may be present at very low flow rates, which could not be attained in the present experiments. This regime is characterized by the absence of the peripheral annulus and by direct fiber-wall friction. It has been postulated by several investigators, to explain friction-loss curves much steeper than in the laminar regime *0–1*.

The same descriptions can be obtained from the τ_w versus $8V/D$ diagrams. Moreover the following are directly apparent:

1. The "laminar" resistance with suspensions may be many times the magnitude for Newtonian fluids.
2. With increase in velocity in a given tube the laminar wall shear increases at a much lower rate than for Newtonian fluids.
3. On the transition to turbulence the resistance drops below that for Newtonian fluids (reaching a maximum difference near the end of the transition region *1–3*).
4. With increase in velocity in a given tube the turbulent wall shear increases at a faster rate than for Newtonian fluids, asymptotically approaching the Newtonian value at high velocities. Note that this asymptotic value corresponds to the friction factor f which is not a constant but decreases with velocity.

These findings are important clues to an adequate description of the mechanics of flow in the three regimes.

Characteristics of the Wood Pulp Fibers

A cross-comparison of the flow-resistance data shows the following:

Laminar Regime

1. For the same velocity and pipe size, f, for any one pulp, increases with concentration.
2. For the same velocity, concentration and pipe size, $f_{LL\ 17} > f_{CR\ 55} > f_{GW}$. The only exception is 1% groundwood, for which in both pipes $f_{LL\ 17} > f_{GW} > f_{CR55}$.
3. For any one fiber at the same concentration and Reynolds number, f is larger for the 2-in. pipe than for the $^3/_4$-in. pipe.
4. For any one fiber at the same concentration and flow velocity, f is approximately the same for the 2-in. pipe and for the $^3/_4$-in. pipe.

The variation of f with pulp type, $f_{LL\ 17} > f_{CR\ 55} > f_{GW}$, indicates that the friction factor increases with the length-to-diameter ratio (see Table II), and the flexibility and hence the interlocking tendency of the fibers. The switch in the relative magnitude of the f values for Coosa River and groundwood at the 1.0% concentration is attributed to the following mechanism: Groundwood requires a higher concentration than the two other pulps before sizable interlocking occurs; when interlocking does finally take place, a not very flexible network is formed, so that a greater friction loss is incurred in moving the suspension at 1% concentration than a corresponding Coosa River suspension. The friction loss in Long Lac 17 remains higher,

Table V. Velocity Profile Tests

Reynolds Numbers for various concentrations in 2-in. diameter tube

		Water		
		9.6×10^4		
		1.55×10^5		
		2.05×10^5		
		Long Lac 17		
0.1%	*0.25%*	*0.5%*	*0.75%*	*1.0%*
		1.08×10^5		
1.55×10^5	1.55×10^5	1.55×10^5	1.55×10^5	1.55×10^5
		2.24×10^5	2.02×10^5	
		Poplar Groundwood		
		0.5%	*0.75%*	*1.0%*
		1.0×10^5	9.4×10^4	
				1.67×10^5
		2.26×10^5	1.87×10^5	2.26×10^5

as Long Lac 17 forms a stronger network than Coosa River 55. The shift in behavior of groundwood at 1% is in the direction of results reported by Brecht and Heller (*9*) for a 3% concentration, at which f was found to be larger for groundwood than for other, longer fibers.

Transition Regime

1. For the suspensions of longer fibers (Long Lac 17 and Coosa River) the transition regime is well developed, occurring over a wide range of flow rates (or wall shear stresses). The experimental points in the f versus **R** and τ_w versus $8V/D$ plots can usually be connected by a series of straight lines of slopes gradually approaching that of the turbulent regime. The number of these straight lines of intermediate slope increases with concentration.

2. For the suspensions of the short groundwood fibers the transition occurs much more abruptly, and turbulent conditions are attained within a narrow range of flow rates after the end of the laminar regime. In the f versus **R** diagrams the experimental points usually form "valleys" at the end of the laminar regime. The valleys are also present in some of the runs with the other two pulps.

Turbulent Regime

1. f decreases with concentration, the decrease being particularly marked at high concentrations.

2. f decreases as fiber length increases (i.e., in general, $f_{GW} > f_{CR\ 55} > f_{LL\ 17}$).

3. f decreases as pipe size increases, particularly at the higher concentrations.

4. The slope of the f versus **R** line is flatter than for water so that f approaches the Newtonian value at high Reynolds numbers.

In some cases (particularly for Long Lac 17 for which, on account of its extended transition, the portion of the turbulent regime which could be covered in the tests was very limited) it was difficult to draw best-fit lines through the experimental points. Also note that for the 1% Coosa River in the $^3/_4$-in. pipe, at the higher flow rates, the flow was apparently still in transition.

Characteristics of the Nylon Fibers

The significant comparisons between nylon tests and the wood pulp behavior can be summarized as follows:

1. The longer and more flexible nylon show more pronounced deviations from Newtonian behavior than any of the several wood pulps.

2. In the laminar regime the 0.2-in. 1.5-denier nylon at a fixed concentration and flow velocity gives f higher in the 2-in. pipe than in the $^3/_4$-in. for 0.1% and 0.25%, but the relation reverses to a small degree for the 0.5% concentration. This is in contrast to the findings for laminar flow of wood pulps where at the same concentration and velocity f is essentially the same. A definite channel-size effect is indicated, implying that the clear-water annulus behavior depends on the scale of the flow for those fibers.

3. In the laminar range the slopes of the f versus **R** lines differ somewhat from those for the wood pulp fibers, also indicating a difference in the clear-water annulus behavior.

4. The beginnings of the transition to turbulence, as evidenced by breaks in the laminar f lines, did not fall in a consistent pattern. In some cases the laminar flow appeared to extend to f values below the Newtonian curve. In other cases the break appeared earlier. This and the general test experience of difficulty in obtaining the measurements suggests the possibility of a tendency toward instability and hysteresis in this region of the f versus **R** diagram.

5. In the transition and turbulent flow regimes the nylon shows, in general, a higher friction loss than the wood pulp suspensions at the same flow rate. This seems to be due to the difference in fiber length and flexibility, both factors working toward a statistically more extensive fiber network and more momentum transfer directly through the fibers themselves.

In other respects the nylon behaves similarly to the wood pulps.

Velocity Profiles: Reynolds Number, Fiber Type, and Concentration Effects

Velocity profiles were obtained in the 2-in. horizontal tube at flow rates above the velocity of breakup of plug flow. Measurements were made for water and for Long Lac 17 and groundwood suspensions. The latter two represent the extremes in fiber length, flexibility and other characteristics of the natural fibers. From the flow resistance data it appeared that more information regarding the mechanics of the turbulent flow could be obtained by traverses for velocity (and turbulence) with these stocks than with any other combination.

Test combinations for which profile data are given are shown in Table V. In selecting the test conditions for the traverses it was assumed that the greatest effect of fiber additions should be when the difference between friction factors for the suspension and water is the greatest. This occurs at the beginning of the turbulent regime as previously defined. The test combinations were selected to fall in this early turbulent range as far as possible. For Long Lac 17 at 1% this was not possible since it appears from the resistance data that the flow is still in the transition regime at the highest velocities attainable. A range of velocities (or Reynolds numbers) was covered, and for purposes of comparison almost the same values were used for water and both the fibers.

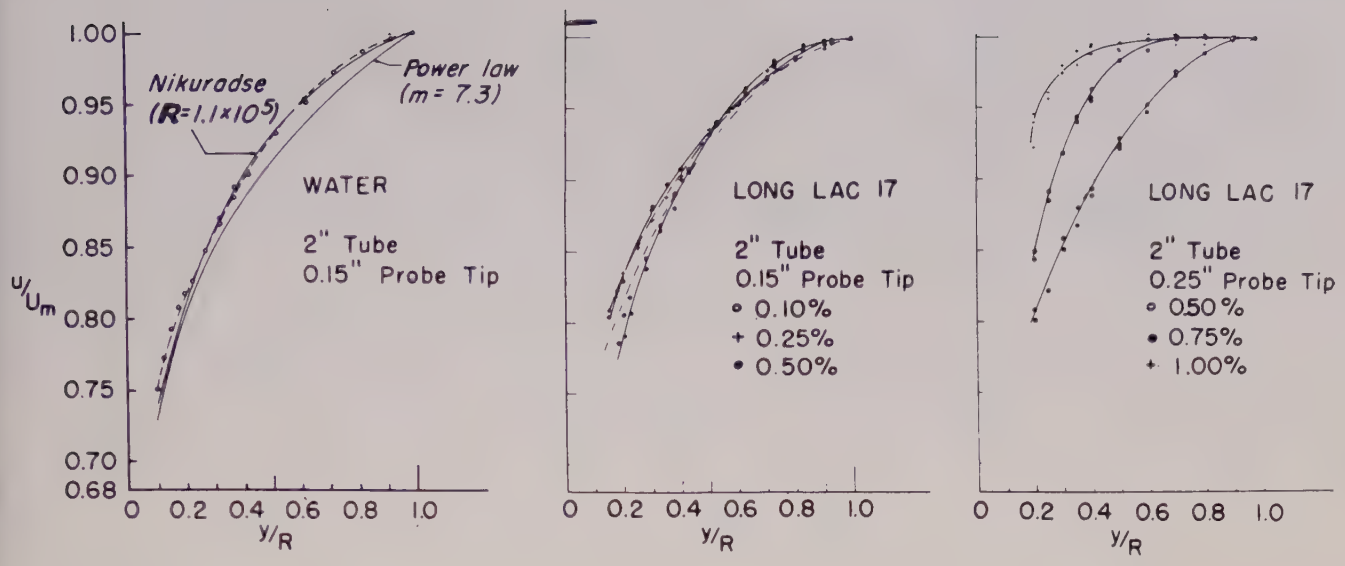


Fig. 20. Dimensionless Velocity Profiles

Concn. effects with LL 17; **R** approx. 1.55×10^5

The first measurements were at the constant Reynolds number of approximately 1.55×10^5 with water and with Long Lac 17 at all five concentrations. These results are given (Fig. 20) as dimensionless profiles. Before continuing we should note two things: First, the Long Lac 17 profiles for low concentrations were obtained using the 0.15-in. diameter flat-tip probe. At higher concentrations a 0.25-in. tip was necessary to prevent accumulation of fiber bundles. Both tips were used for 0.5% concentration, with good agreement. Second, in making comparisons attention is directed to the central portion of the profile where measurement accuracy is inherently the best. Measurements near the wall suffer from interference effects between the wall and probe, as already mentioned.

In Fig. 20 a measured water profile is compared with one by Nikuradse [(*46*) Fig. 20.2]. The agreement is good considering the oversized probe used in the present experiments. Next we see the effect of Long Lac 17 concentrations up to 0.5% is small although definite. The deviations from the water profile are in the direction of slowly increasing bluntness with increasing concentration. Above 0.5% concentrations the effect becomes pronounced.

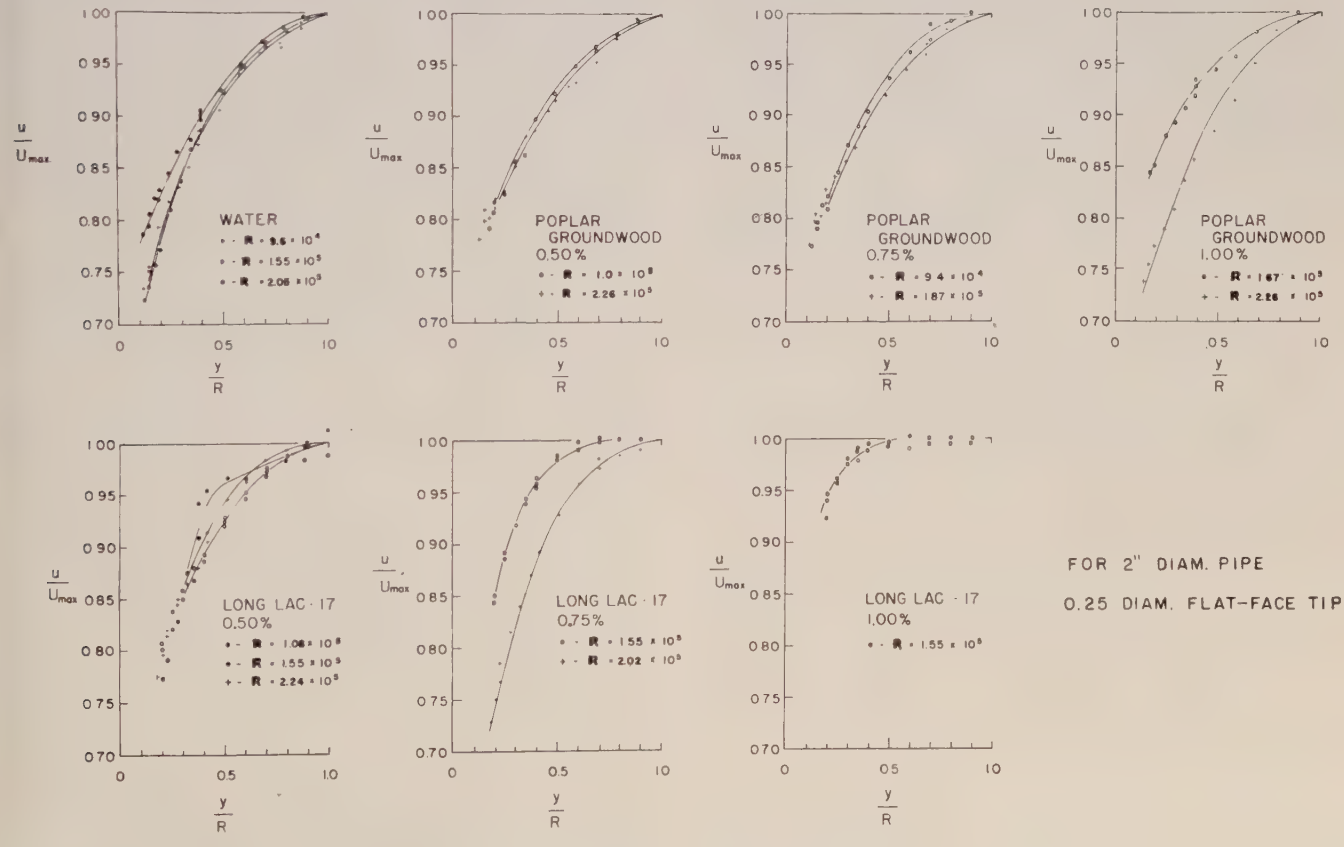


Fig. 21. Dimensionless velocity profiles

R effects at constant concn.

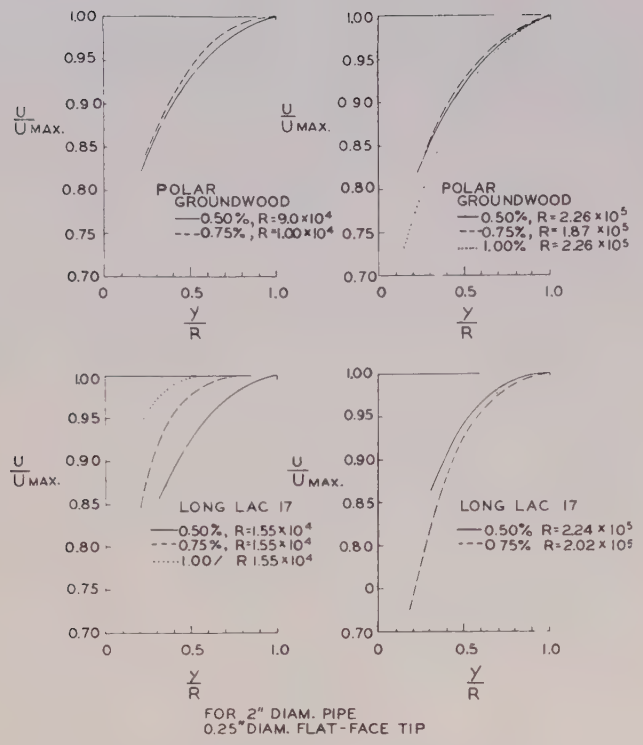


Fig. 22. Dimensionless velocity profiles
Concn. effects at approx. const. **R**

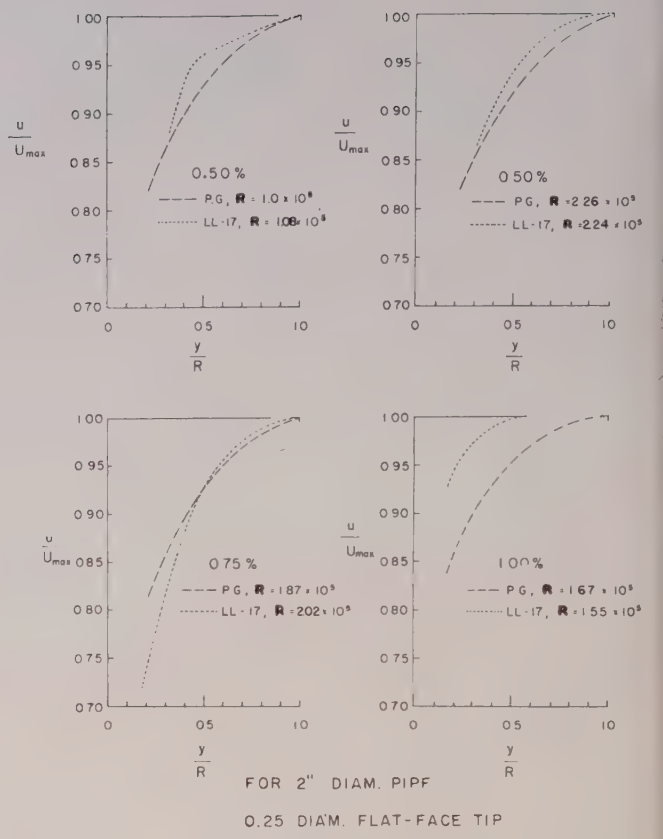


Fig. 23. Dimensionless velocity profiles
Fiber type effects at constant concn. and approx. const. **R**
———— Poplar groundwood; ------ Long Lac 17

Subsequent profiles with fibers were restricted to concentrations of 0.5% and greater. Profiles for several flow rates are shown in Fig. 21 for water and for the two pulps in the 0.5% to 1.0% concentration range. The pulp data are used in Figs. 23 and 24 for cross-comparisons of concentration and fiber-type effects. All the data of Fig. 21 are shown in Fig. 24 as plots of local velocity, u, versus the log of the distance from the wall, y.

The trends shown by all the profiles are summarized as follows:

Reynolds Number Effect (Fig. 21)

1. For water, as the Reynolds number increases the velocity profiles become blunter, as well established by other investigators.
2. For a given fiber and concentration, the profiles become sharper as Reynolds number increases (exception LL 17, 0.5%, $\mathbf{R} = 2.24 \times 10^5$).
3. With fibers the Reynolds number effect is more pronounced at higher concentrations; and, for concentrations up to limit of comparison of 0.75%, is more marked with Long Lac 17 than with groundwood.

Concentration Effect (Figs. 20 and 22)

1. For a given fiber and Reynolds number the velocity profiles become blunter as concentration increases (exceptions GW, 1.0%, $\mathbf{R} = 2.26 \times 10^5$; LL 17, 0.5%, $\mathbf{R} = 2.24 \times 10^5$).
2. The effect is more marked for Long Lac 17 than for groundwood.

Fiber Type Effect (Fig. 23)

1. For a given concentration and Reynolds number, the velocity profiles (a) are blunter for Long Lac 17 than for groundwood over the central portion of the tube, and (b) tend toward being fuller (higher velocities) near the wall for the groundwood than for Long Lac 17.

It will be noted that the trends are interrupted by only two apparent exceptions, both involving runs at the highest velocities. In general, at high velocities with high concentrations, air entrainment was troublesome. In the questionable runs this was especially so.

COMMENTS ON FLOW MECHANICS WITH FIBERS

We have already noted the well-known plug flow of laminar motion with its core of entangled fibers surrounded by a lubricating annulus. This will be discussed in detail in a later article. We will close with a few remarks about the role of fibers in turbulent flow as indicated by the velocity profiles and the flow resistance charcteristics. The observations will be qualitative, reserving a detailed analysis of the turbulent regime until a later presentation of turbulence measurements.

The velocity and resistance data indicate:

1. For Newtonian fluids, increasing the velocity results in both blunter profiles and increasing wall shear.
2. For fibers, increasing the concentration at constant velocity gives both blunter profiles and reductions in τ_w below the Newtonian value.
3. For fibers, increasing the velocity gives sharper profiles and a higher rate of increase in τ_w than for Newtonian fluids.
4. For both suspensions and Newtonian fluids, the flow at every radius is subject to shear.

Assume now that the mechanism of transmitting shear from the wall into the flow is similar to the Newtonian case in that at the wall there is a laminar sub-

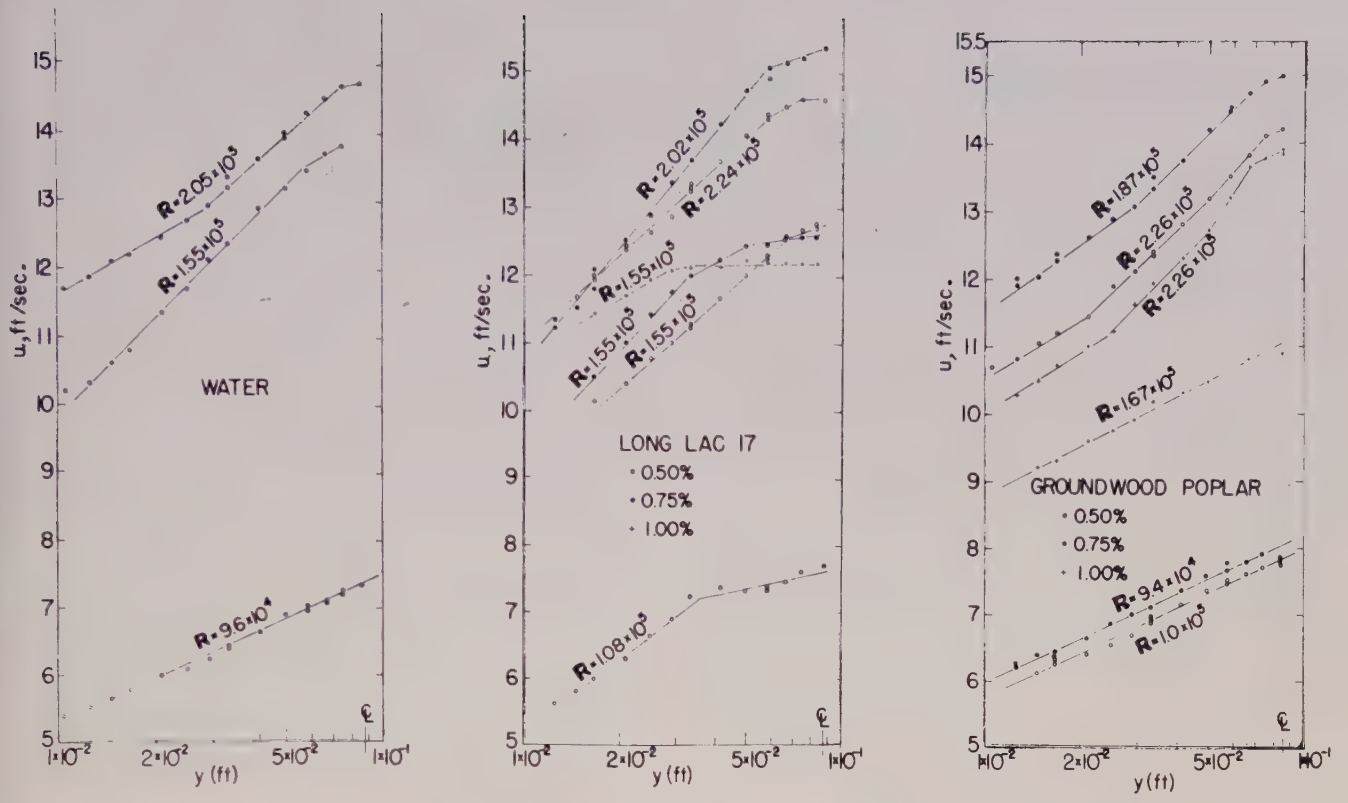


Fig. 24. Velocity profiles—Semi-log plot

layer in which the shear is viscous and proportional to the velocity gradient $(du/dy)_w$. It follows from (2), above, that $(du/dy)_w$ is less than the Newtonian unless the local viscosity is reduced by adding fibers, which is improbable. Then a lower $(du/dy)_w$ is possible with the blunter fiber profile only if, as the wall is approached, the means of transmitting shear becomes weaker than for the Newtonian fluid. This suggests a different turbulence structure than in Newtonian fluids. On the other hand, a zero velocity gradient will not transmit shear by the usual hydrodynamic means, so (4) implies a transmission mechanism over the blunt portion of the profile which involves the fibers positively. Item (3) accounts for τ_w approaching the Newtonian value and indicates reduced importance of suspension effects as the velocity becomes very large. The role of the fibers might be described as follows:

In the suspensions the fibers cluster. Each cluster has a tendency to interlock with the neighboring ones. Interlocking opposes the action of the shear stresses and results in a blunter velocity profile (concentration effect). For a particular concentration, as the flow rate (and hence the magnitude of the shear stresses) increases, the equilibrium between disruptive action of the shear stresses and interlocking shifts more in favor of the shear stresses; the links between fiber clusters are more effectively disrupted, and the velocity profiles become sharper (Reynolds number effect). At the lower concentrations, the links between the clusters are weak, and the velocity distribution is not very different from Newtonian; thus, an increase in the shear level can cause no major changes in the velocity profiles.

At the higher concentrations, the links are stronger, and the velocity profiles are blunter than the corresponding Newtonian ones (concentration effect). In this case an increase in shear level can cause a much more marked change in the velocity profiles. The progressive weakening of the link resistance leads to velocity distributions tending to those for water. It appears that at sufficiently high shear stresses the flow should become fully Newtonian. However, this may be approached only asymptotically.

The blunter velocity profiles of the Long Lac 17 suspensions as compared with those of the groundwood suspensions at the same Reynolds number and concentration (fiber type effect) confirm the role played by fiber length and flexibility in the strength of the links between fibers and fiber clusters. The Long Lac 17 fibers, which are much longer and more flexible than the groundwood fibers (Table II), have a more pronounced tendency to interlock. Stronger bonds between fibers or fiber clusters, and hence blunter velocity profiles, result.

CONCLUSIONS

We have presented measurements of flow resistance for wood pulp and nylon fibers and turbulent flow velocity profiles for wood pulp fibers which, together, form a set of basic data of broad general usefulness. The fibers used cover a wide range of physical characteristics.

The data in general show evidence of the laminar, transition, and turbulent flow regimes reported by previous investigations of dilute suspensions. In addition to the better-known characteristics of dilute suspensions, a comparison of the flow resistance and velocity profiles brings out the following unique points:

1. Wood pulp and nylon fiber show generally similar flow resistance characteristics indicating similar effects of the several physical properties on the hydrodynamic conditions. There is some indication that with the longer, more flexible nylon fibers the clear-water annulus behavior of the laminar flow regime may depend on scale.

2. With increasing length-to-diameter ratio and flexibility, increasing departures from Newtonian behavior occur in the flow resistance and velocity profiles.

3. At low velocities the flow resistance measurements are generally consistent with the clear-water annulus concept. The character of the transition to turbulence depends very much on the fiber properties, being abrupt for the short stiff groundwood fibers and extending over a flow range for the other fibers.

4. In the early turbulent regime, velocity profiles tend to be flat with the friction factor (and wall shear) lower than Newtonian values, suggesting both a turbulence different from the Newtonian and a combined role of turbulence and fiber entanglement in the actual flow mechanics.

5. With increasing velocity the friction factor and velocity profiles tend toward the Newtonian, indicating an approach to Newtonian-type turbulent flow behavior.

A brief qualitative description of the role of fibers and turbulence is given based on these and other findings.

Detailed analyses and discussions of the three main flow regimes will be presented in later articles.

LITERATURE CITED

1. Agoston, G. A., *et al.*, *Ind. Eng. Chem.* 46, 1017–1019 (May, 1954).
2. Alfrey, T. and Gurnee, E. F., "Rheology," Chapt. 11, New York, Academic Press, Inc., 1956.
3. Baines, W. D., "Symposium on Flow of Suspensions," pp. 39–58, Ottawa, Ont. Canada, National Research Council of Canada, November, 1956.
4. Baines, W. D., "Laminar Flow of Dilute Fiber Suspensions." Report MH-73, Ottawa, National Research Council, 22 August, 1958.
5. Bakhmeteff, B. A., "The Mechanics of Turbulent Flow," Princeton University Press, 1936.
6. Bakhmeteff, B. A. and Allan, W., *Transactions, ASCE*, 111, 1043–1102 (1946).
7. Baldwin, P. C. and Van den Akker, J. A., *Paper Trade J.* 109, No. 12: 151–156 (Sept. 21, 1939).
8. Barlow, J. S. and Brown, R. M., "An Analog Correlator System for Brain Potentials," T.R. 300, MIT Research Laboratory of Electronics, July, 1955.
9. Brecht, W. and Heller, H., *Tappi* 33, No. 9: 14A–48A, (Sept., 1950).
10. Bryant, E. O., "A Photographic Method for Hydrodynamic Research and Its Applications to the Motions of Fibers in Flow Suspensions," Doctor's Dissertation, Institute of Paper Chemistry, Appleton, Wis., June, 1937.
11. Chien, Ning, *Transactions ASCE*, 121, pp. 833–884, (1956).

12a. Daily, J. W. and Bugliarello, G., "The Characteristics of Flow with Dilute Fiber Suspensions," T.N. No. 2, Hydrodynamics Laboratory, MIT, Dec., 1957.

12b. Daily, J. W. and Bugliarello, G., "The Effects of Fibers on Velocity Distribution, Turbulence and Flow Resistance of Dilute Suspensions," T.R. No. 30, Hydrodynamics Laboratory, MIT, Oct., 1958.

12c. Daily, J. W. and Tsuchiya, A., "Flow of Nylon Fiber Suspensions—A Progress Report," T.N. No. 4, Hydrodynamics Laboratory, MIT, Feb., 1959.

12d. Daily, J. W., Bugliarello, G., and Troutman, W. W., "Measurement and Analysis of Turbulent Flow of Wood Pulp Fiber Suspensions," T.R. No. 35, Hydrodynamics Laboratory, MIT, Sept., 1959.

13. Dodge, D. W. and Metzner, A. B., "Turbulence in Non-Newtonian Systems," Report, University of Delaware, Dept. of Chemical Engineering, Feb., 1958.
14. Durst, R. H. and Jenness, L. C., *Tappi* 37, No. 10: 417–422, (Oct. 1954); *Tappi* 38, No. 4: 193–198, (April, 1955); *Tappi* 39, No. 5: 277–283, (May, 1956).
15. Forgacs, O. L., Robertson, A. A., and Mason, S. G., "Proceedings, 44th Annual Meeting of the Technical Section, Canadian Pulp and Paper Association," pp. 79–90, Montreal, Que., Jan., 1958.
16. Forrest, F. and Grierson, G. A. H., *Paper Trade J.* 92, No. 22: 39–41, (May 28, 1931).
17. Goldstein, S., ed., "Modern Developments in Fluid Dynamics," Vol. II, Oxford, Clarendon Press, 1938.
18. Gray, J. L. and Van den Akker, J. A., *Paper Trade J.* 118, No. 17: 29–34 (April 27, 1944).
19. Guenther, T. E. and Ceaglske, N. J., *Tappi* 34, No. 3: 140–144 (March, 1951).
20. Guthrie, W. E., *Tappi*, 42, No. 3: 232–238 (March, 1959).
21. Head, V. P., *Tappi* 35, No. 6: 260–266 (June, 1952).
22. Head, V. P. and Durst, R. W., *Tappi* 40, No. 12: 931–936 (Dec., 1957).
23. Institute of Paper Chemistry, "Physical Properties of Fibers Used in MIT Study under TAPPI Project 93," Mimeographed Report, Appleton, Wis., 1958.
24. International Telegraph and Telephone Corp., Reference Data for Radio Engineers," 4th Edition, 1957.
25. Ippen, A. T., Tankin, R. S., and Raichlen, F., "Turbulence Measurements in Free Surface Flow with an Impact Tube—Pressure Transducer Combination," T.R. No. 20, Hydrodynamics Laboratory, MIT, July, 1955.
26. Ippen, A. T., Daily, J. W., and Bugliarello, G., *Tappi* 40, No. 6: 478–485 (June, 1957).
27. Ismail, H. M., *Transactions, ASCE*, 117, pp. 409–446 (1952).
28. Kline, S. J. and Runstadler, P. W., *J. Appl. Mech.* 26, No. 2:166–170 (June, 1959).
29. Laufer, J., "Investigation of Turbulent Flow in a Two-Dimensional Channel," Report 1053, NACA, 1951.
30. Laufer, J., "The Structure of Turbulence in Fully Developed Pipe Flow," Report 1174, NACA, 1954.
31. Mardon, J. and Van der Meer, W., *Pulp and Paper Magazine of Canada*, 55, No. 2: 107–127 (Oct., 1954).
32. Mason, S. G., Robertson, A. A., Allen, G. A., and Walker, C. W., *Pulp and Paper Magazine of Canada* 55, No. 7: 97–108 (Aug., 1954).
33. Metzner, A. B., "Advances in Chemical Engineering," vol. I, Chap. II, New York Academic Press, Inc., (1) 956.
34. Metzner, A. B., *Ind. Eng. Chem.* 49, No. 9: 1429–1432 (Sept., 1957).
35. Metzner, A. B. and Reed, J. C., *AIChE Journal* 1, No. 4: 434–440 (Dec., 1955).
36. Mooney, M., *J. of Rheology* 2, No. 2: 210–222 (April, 1931).
37. Moss, L. A. and Bryant, E. P., *Paper Trade J.* 106, No. 15: 46–57 (April, 1938).
38. Moss, L. A., "A Photographic Study of the Motion of Fibers and Water in Flowing Fiber Suspensions," Doctor's Dissertation, Institute of Paper Chemistry, Appleton, Wis., June, 1937.
39. Nilson, B. M., "Investigation of Friction Losses Encountered in Connection with Pulp Flowing in a Straight Pipe," originally published in *Svensk Papperstidn.* 15 (Aug. 15, 1944), Mimeographed Abstract by K. J. Makenzie of the Translation by S. A. Quist.
40. Rabinowitsch, B., *Zeitschrift für Physikalische Chemie* 145A, No. 1: 1–26 (1929).
41. Richardson, R. J., "The Flow of Wood Pulp Slurries," Sc.D. Thesis in Chemical Engineering, MIT, June, 1954.
42. Rivlin, R. S., *Quarterly of Applied Mathematics* 15, No. 2: 212–215 (July, 1957).
43. Robertson, A. A. and Mason, S. G., *Pulp and Paper Magazine of Canada* 57, No. 6: 121–123 (May, 1956).
44. Robertson, A. A. and Mason, S. G., "Symposium on Flow of Suspensions," pp. 9–38, Ottawa, Ont., National Research Council of Canada, Nov., 1956.
45. Robertson, A. A. and Mason, S. G., *Tappi* 40, No. 5: 326–334 (May, 1957).
46. Schlichting, H., "Boundary Layer Theory," New York, McGraw-Hill, 1955.
47. Shaver, R. G., "Turbulent Flow of Pseudoplastic Fluids in Straight Cylindrical Tubes," Sc.D. Thesis in Chemical Engineering, MIT, Sept., 1957.
48. "Standards of Hydraulic Institute," Standard E, E(III) pp. 1–10, New York, Hydraulic Institute, 1957.
49. Starkey, T. V., *Brit. J. Appl. Phys.* 7, No. 2: 52–55 (Feb., 1956).
50. Townsend, A. A., "The Structure of Turbulent Shear Flow," Cambridge University Press, 1956.
51. Troutman, W. W., "Interim Progress Report on TAPPI Research Project No. 93," Section 2, MIT, Feb., 1957.
52. Troutman, W. W., "Techniques for Velocity and Turbulence Measurements in Fiber Suspensions," M.S. Thesis in Civil Engineering, MIT, Sept., 1958.
53. Van den Akker, J. A., *Pulp and Paper Magazine of Canada* 55, No. 13: 91–96 (Dec., 1954).
54. Vanoni, V. A., *State University of Iowa Studies in Engineering Bull.* 34, pp. 137–158 (1953).

Precision Paper Cutter

W. A. WINK

A guide-equipped paper cutter for the preparation of accurately cut test specimens, as required for the physical evaluation of paper and paperboard, is described. The guide is of a design which ensures parallel cutting of test strips for a wide choice of preset dimensions. Several thicknesses of paper of medium weight may be cut simultaneously, thus expediting the cutting operation, and the cutting may be done without touching the test area of the sample; a feature of importance to many physical measurements.

FOR THE physical evaluation of paper and paperboard there is often a need for accurately cut test specimens and, more often than not, the cutting tends to be repetitious. The preparation of accurately cut specimens is an exacting and time-consuming job that is only partially eased through the use of commercially available specimen cutters. These specimen cutters are usually designed specifically for a given application; consequently, they are not always applicable to the cutting problems one encounters in control or research work.

The problem of precision cutting of test specimens has been handled in this laboratory by modifying a common paper cutter and equipping it with a guide and clamp. This arrangement serves as a means for firmly gripping the paper sample for the cutting operation and it is of a design which ensures parallel cuts for a wide choice of preset dimensions. Experiences with two guide-equipped cutters have shown that several thicknesses of paper can be cut simultaneously with good accuracy, thus expediting the cutting operation, and that the cutting may be done without touching the test area of the sample, a feature of importance to many of the physical measurements.

The following section of this paper presents a description and detailed drawings of the guide-equipped cutter.

DESCRIPTION

A photograph of the cutter equipped with the guide is shown in Fig. 1. In many respects the guide resembles a draftsman's tee square and triangle—actually, its operation is based on the same principle. The member *A*, which corresponds to the tee square in this case and which contains four notched bars, is securely fastened to the bed of the cutter at an angle of 90° with respect to the stationary knife *B*. The member *C*, which corresponds to the triangle, holds a clamp for securely gripping the sample for the cutting operation. The four notched bars, any one of which is easily removed and replaced by another, provide for the cutting of specimens of the desired dimensions. For the arrangement shown, one bar provides for the consecutive cutting of 15-mm. strips, a second for the consecutive cutting of 1-in. strips and the third and fourth for the cutting of specimens of unequal width—for example, successive specimens 15 mm., 1 in., and 63 mm. wide, as required for the determination of folding endurance, tensile strength and tearing resistance, respectively. Various other cutting combinations may, of course, be obtained by merely exchanging the bars described with a bar having milled notches of the desired spacing.

The selection of any one of the cutting combinations provided by the four bars is accomplished by merely positioning the pawl *D* over the bar having the desired spacing between notches. This pawl is spring-loaded and engages with the notches; it is mounted on a grooved shaft and can be moved from one bar to another by merely loosening the set screw *E* (by hand). The end of this set screw is turned down to a diameter somewhat smaller than the nominal diameter of the screw (to remove the threads) and the machine-finished

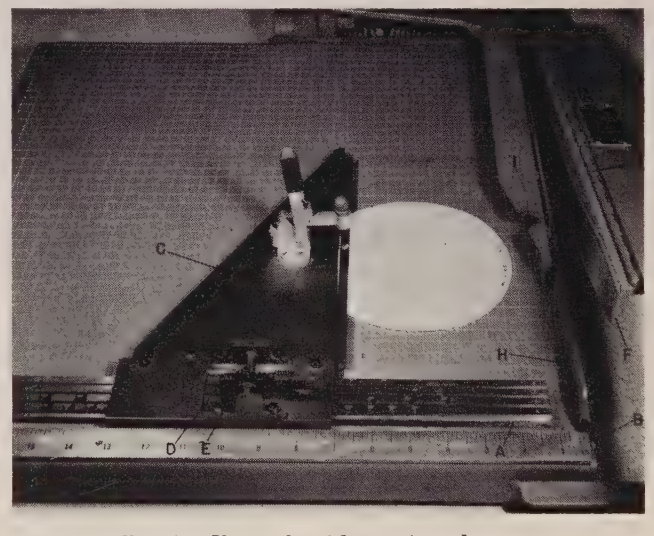


Fig. 1. View of guide-equipped cutter

end extended into any one of four grooves on the shaft; this serves to keep the pawl aligned with a given bar.

To illustrate the way in which the guide-equipped cutter is used, let it be assumed that it is desired to cut two 15-mm. wide strips and one 63-mm. strip (as required for folding endurance and tearing resistance) from the handsheet clamped in the guide. Accordingly, the pawl *D* is positioned over the appropriately notched bar and the guide is moved to the right until the pawl engages with the first notch on the bar. This function is easily performed with the operator's left hand while the right is free for handling the cutter. Once the pawl has dropped into the notch, the guide is moved back so that the pawl is seated against the vertical left side of the notch and the member *C* bears against the member *A*. The guide is held firmly in this position while the cut is made. The first or trim cut "squares" the freshly cut edge of the sample with respect to the cutter knives and the guide; this, it will be noted, is one

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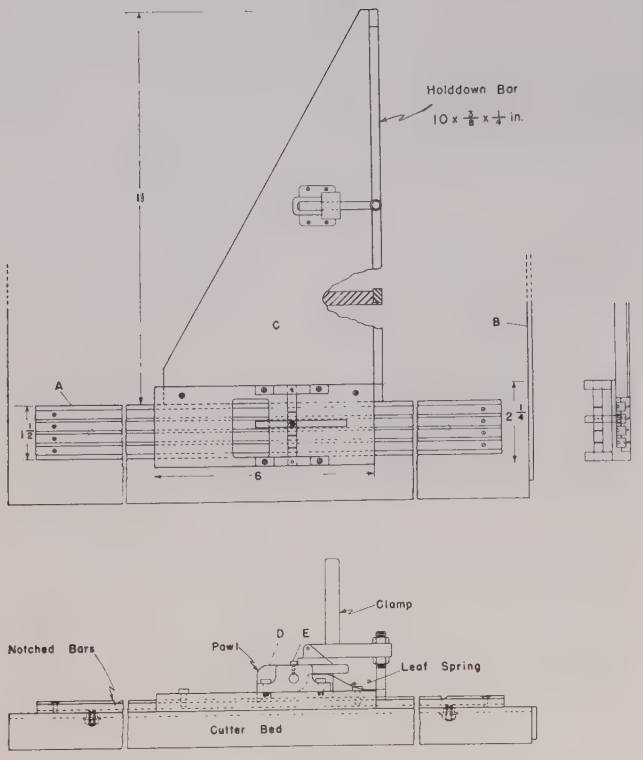

Fig. 2. Detailed drawing of guide

of the important features of the guide and results in the cutting of specimens having parallel edges. Subsequently, the guide is moved to the right to engage the pawl with the second notch, displaced 15 mm. from the first; the cut in this position produces the first 15-mm. strip. Continuing with this procedure, engagement of the pawl in the third notch produces the second 15-mm. strip and the fourth notch the 63-mm. strip. The guide is returned to its starting position, in preparation for the cutting of another sample, by depressing the pawl and sliding the guide to the left. Experience has shown that at least five handsheets of standard weight, or a similar number of machine-made papers, can be cut simultaneously with good dimensional accuracy and with all edges of the cut strips parallel to each other.

The cutter itself is a commercial type* and of steel construction; it embodies at least three features of importance to this application: (1) The cutter is sturdy and rigid in construction and thus offers a good base upon which to mount the guide. (2) The cutter knives are mounted in such a manner that small amounts of knife wear do not seriously alter the performance of the cutter. The movable knife *F* is attached to the cutter handle by means of the hinge *G;* this knife is spring-loaded to ensure that it will bear against the stationary knife *B* with a uniform force. (3) The holddown bar *H* serves the useful function of holding the sample securely in place (prevents slippage) while the cut is made. The operation of this bar is linked with the operation of the cutter; i.e., it is raised and lowered automatically as one raises and lowers the cutter handle. The surface of the bar that contacts the sample is comprised of rubber.

In order to utilize cutters, not originally intended for precision work, experience has indicated that minor but important modifications on the cutter itself are required. These are: (1) Stationary knife *B* must be perfectly straight in order to obtain straight-edged specimens. This condition has not existed on cutters purchased for use in this laboratory; however, it was corrected by the simple expedient of removing burrs inadvertently left around drilled and tapped holes, and on the surface against which the knife is attached to the side plate of the cutter. (2) The cutting edge of the stationary knife must lie in the plane of the top surface of the cutter bed in order to avoid serious bending or distortion of the sample during cutting. This condition exists to a satisfactory degree when using new cutter knives, but as the knife depth is reduced due to sharpening a provision for vertical knife adjustment is required. Slotting the holes in the side plate of the cutter and replacing the screws provided (for attachment of the knife) with flat-head bolts of appropriate size facilitates this necessary adjustment. (3) To avoid distortion of the sample while cutting it is important that the holddown bar be located as near as possible to the knives. This is particularly important for the cutting of lightweight tissues or glassine. On cutters as normally supplied, the holddown bar was positioned at a distance too far away from the knives for optimum performance. This condition was rectified by placing shims between member *H* and *I*, as shown in the photograph. Figure 1 shows the holddown bar in a slightly raised position; thus, the alignment and position of the bar are not clearly evident in the view shown. (4) A cutout in the member *I* is required to accommodate the sample clamp so that cuts close to the guide can be made.

Details of a guide suitable for mounting on a 20-in. cutter are shown in Fig. 2. The guide is of steel construction and all components are fabricated from ground stock. With the exception of the notches which govern the cutting distances, the dimensions of the guide are not critical. The member *C* is $^3/_8$-in. thick, and the member *A*, which holds the four notched bars, is $^1/_4$-in. thick and approximately 18 in. long. The notched bars are $^1/_4$-in. square and also 18 in. long; they are mounted in milled grooves in the base plate *A* and are held in position at each end with flat-head screws. The clamp† is commercially available and is of a type that opens wide for easy inserting of samples. Although it is not evident in the drawing, the holddown bar of this clamp is *very* slightly curved so that, when the clamp is closed, effective gripping of the sample along its entire length is achieved.

Individual requirements may vary widely so that in some instances only one notched bar is required. In this event, the construction of the guide can be simplified by merely mounting a single notched bar (suggested size $^1/_4$ by 1 in.) on the bed of the cutter and mounting the pawl in a fixed position. Other modifications are obvious; however, if more than four bars are used, it is recommended that the diameter of the grooved shaft which supports the pawl be increased for increased stiffness.

* Jacques Jr. table model paper cutter, size 20-in., manufactured by the Hobbs Manufacturing Co., 26 Salisbury St., Worcester 5, Mass.

† De Sta Co. Clamp No. 202 may be purchased from: Triplex Supply Co., 830 North Third St., Milwaukee 3, Wis.

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A Search for New Fiber Crops

Part IV. Kenaf Composition

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The compositional characteristics of kenaf (*Hibiscus cannabinus*), a tall, fast-growing annual plant adapted to many areas of the United States, indicate that it merits consideration as a source of pulp fiber.

EARLIER papers of this series (*1–3*) have included results of comparative laboratory data on many plant species presently uncultivated as crops, but which appeared to merit evaluation as pulp and papermaking raw materials. On the basis of these experimental findings, kenaf is one of several species chosen for more detailed study. The chemical and physical composition of selected kenaf plantings grown in the United States are presented. Pulping characteristics and properties of paper from kenaf will appear in a later publication.

Botanically, kenaf (*Hibiscus cannabinus*) belongs to the family Malvaceae. Okra (*H. esculentus*) and roselle (*H. sabdariffa*) are closely related species; cotton (*Gossypium* sp.) is also a member of this family. Kenaf is a fast-growing annual with woody stalks 6 to 12 ft. tall and up to 1 to 2 in. in diameter (depending in part on planting density). The stalks are mostly unbranched in dense plantings.

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Kenaf has long been cultivated in many parts of the world under a variety of local names (*4*) as a source of bast (or bark) fibers. These fibers are similar to jute and comprise about 20% of the dry weight of the stalks; they serve as coarse textile fibers for manufacturing twine, burlap, carpet backing, and related products. More recently, kenaf has been experimentally cultivated for its bast fiber in the Western Hemisphere (*5*), including selected areas of the United States (*6*). In contrast, we have chosen to investigate the entire kenaf stalk including both outer (bast) and interior (woody) fibers.

EXPERIMENTAL

Materials

All kenaf used was grown by or for the Crops Research Division of the Agricultural Research Service, U. S. Department of Agriculture, in Illinois, Florida, Michigan, Missouri, Indiana, Nebraska, Oklahoma, and Texas. Numerical designations for varieties (or selections) are those in use by that group. These designations are Cubano, Cuba 108, Salvadorian, 52–1, 52–7, 52–33, 52–41, 52–71, 53–30, 53–32, 53–46, 53–53, 53–58, and Sc–28. Whole stalks were harvested between 2 weeks and 2 months after frost, except in Florida and in one instance in the Midwest when it was desired to

Table I. Compositional Data on Kenaf

Crop year	Location	No. kenaf types analyzed to obtain data	Chemical analyses: Cellulose, ash-free, Crude, %	Pentosan-free alpha, %	Solubility: 1% NaOH, %	Alcohol-benzene, %	Ash, %	Lignin, %	Pentosans, %	Physical analyses: Arithmetic averages: Fiber length, mm. Bast	Fiber length, mm. Woody	Fiber width, μ Bast	Fiber width, μ Woody	Stalk density, g./ml.	Yield of stalk macerate[a]: Bast, %	Woody, %
1957	Urbana, Ill.	14–harvested after frost (Dec. 2)	52.9	35.7	31.0	3.6	2.0	17.8	20.7	2.66	0.63	22.5	39.6	..	21.4	33.3
1957	Urbana, Ill.	14–harvested before frost (Sept. 27)	46.9	31.5	40.1	9.5	4.5	14.7	20.4	2.78	0.49	19.2	37.9	..	25.2[b]	29.7[b]
1957	Belle Glade, Fla.	10–98 growing days	56.2	39.4	29.2	4.4	4.6	17.7	21.4	2.51	0.60	19.4	40.5	..	24.4	31.2
1957	Belle Glade, Fla.	1–100 growing days	57.0	38.9	30.2	4.9	3.3	16.5	22.9	2.47	0.63	19.8	29.5	..	18.3	25.1
1957	Belle Glade, Fla.	1–121 growing days	55.0	37.8	31.6	3.7	5.0	17.8	21.1	2.30	0.56	19.1	28.9	..	18.3	21.8
1957	Belle Glade, Fla.	1–152 growing days	56.1	38.9	29.7	4.6	4.1	17.2	21.7	2.50	0.70	17.2	27.2	..	19.3	23.8
1957	Belle Glade, Fla.	1–175 growing days	56.9	39.4	28.8	4.3	3.9	18.7	22.1	2.20	0.55	18.5	30.5	..	18.5	27.4
1957	Peoria, Ill.	3	47.1	31.6	34.6	2.5	1.7	14.5	20.1	2.43	0.59	18.3	33.5	..	24.5	20.1
1958	Britton, Mich.	3	55.5	37.9	32.6	3.3	..	..	..	2.77	0.54	24.4	43.0	..	28.6	34.9
1958	Urbana, Ill.	3	56.2	39.1	29.3	3.3	..	..	..	2.71	0.59	21.0	38.6	..	25.2	36.3
1958	Columbia, Mo.	3	50.6	34.6	33.8	6.9	..	..	..	2.75	0.56	21.8	36.4	..	22.7	34.9
1958	Lincoln, Neb.	3	52.4	36.0	34.2	4.1	..	..	..	2.60	0.57	24.5	40.1	..	24.2	35.3
1958	Lafayette, Ind.	3	55.1	38.3	29.1	3.7	..	..	..	2.82	0.56	20.6	39.7	..	26.8	37.1
1959	Urbana, Ill.	3	53.4	36.3	30.5	3.7	..	..	..	2.58	0.63	20.0	31.9	0.28	21.9	25.9
1959	Carbondale, Ill.	1	53.2	35.3	34.2	3.8	..	..	..	2.76	0.69	15.7	34.6	0.26	18.6	28.0
1959	Carbondale, Ill.	1 (double-fertilizer)	53.4	36.2	32.3	3.9	..	..	..	3.14	0.62	18.5	36.9	0.24	20.6	28.7
1959	Peoria, Ill.	1	53.8	35.9	31.9	3.9	..	..	..	2.52	0.70	12.6	30.0	0.28	17.4	26.6
1959	Belle Glade, Fla.	2	58.3	40.9	25.8	3.0	..	..	..	2.78	0.54	17.6	36.0	0.17	21.9	28.8
1959	Columbia, Mo.	1	49.6	32.8	35.8	6.9	..	..	..	2.43	0.57	19.1	36.8	0.24	18.5	28.2
1959	Lincoln, Neb.	2	49.7	33.9	36.7	4.3	..	..	..	2.65	0.57	15.6	32.0	0.29	20.0	23.7
1959	Lafayette, Ind.	1	56.4	38.9	29.9	3.5	..	..	..	2.62	0.55	22.5	40.4	0.19	20.5	33.0
1959	Stillwater, Okla.	1	45.1	30.0	37.0	4.8	..	..	..	2.68	0.63	20.9	32.8	0.26	24.6	39.8
1959	College Sta., Tex.	1	47.8	31.9	39.7	6.3	..	..	..	2.10	0.62	20.7	31.0	0.32	20.5	22.5
Overall average[c]			53.6	36.7	31.4	4.0	3.1	17.4	21.0	2.60	0.60	20.5	37.4	0.25	22.6	30.6

[a] Airdry basis of original sample.
[b] Average of four samples.
[c] Omits 1957 Urbana samples harvested before frost.

check the effect of maturity on composition. Airdry kenaf was stored inside.

Methods

Analytical procedures are those used previously (*1*), or are TAPPI Standard Methods.

RESULTS AND DISCUSSION

The data shown in Table I are average values obtained from varieties grown at 10 locations during 3 crop years. Differences among varieties grown at the same location in the same year were usually minor. Significant differences in composition were noted between some locations, although replication was usually inadequate for rigorous statistical treatment. Yet the analyses are indicative of the general nature of this raw material.

Kenaf grown at Urbana, Ill., in 1957, showed significant differences between whole stalks harvested before and after frost. The frost-killed stalks had a higher content of cellulose and lignin with less solubles and ash. No change in pentosan content was noted. Florida samples differed little in composition over an extended range of growing times.

A borderline statistical indication that the Cubano variety may have lower alkali solubility and higher cellulose content requires further confirmation. Supporting data for this statement have been omitted, pending verification in future crop years. Since the agronomic selections were made specifically for adaptation in Florida, samples from that location might be expected to be among the highest in contents of cellulose and of bast fiber. This statement is in accord with experimental findings.

Fibers in the bast portion of kenaf are narrower than most wood fibers and range in length from about 1 mm. to almost 10 mm. Their average length is greater than most of the hardwoods and comparable to some softwoods. The longer bast fiber fraction accounts for about one fifth of the dry weight of kenaf stalks. Since this fraction undoubtedly survives pulping operations in higher yield than the woody component of the stalk, a final pulp (at 50% pulp yield) might contain approximately 30 to 40% of these longer fibers. This pulp should be adequate, or even preferred, for many end uses, and this possibility is being tested.

Reliable yield figures in terms of dry matter per acre are not yet available, but will ultimately govern the economics of kenaf utilization. However, perusal of the data on Table I indicates that this plant can be grown in many areas of the United States. A raw material having the compositional characteristics of kenaf should receive serious consideration as a source of papermaking fiber.

LITERATURE CITED

1. Nieschlag, H. J., Nelson, G. H., Wolff, I. A., and Perdue, R. E., Jr., *Tappi* 43, No. 3: 193–201 (March, 1960).
2. Nieschlag, H. J., Earle, F. R., Nelson, G. H., and Perdue, R. E., Jr., *Tappi* 43, No. 12: 993–998 (December, 1960).
3. Nelson, G. H., Nieschlag, H. J., Daxenbichler, M. E., Wolff, I. A., and Perdue, R. E., Jr., *Tappi* 44, No. 5: 319–325 (1961).
4. Crane, J. C., *Econ. Botany* 1–2: 334–350 (1947–48).
5. Walker, J. E. and Sierra, M., "Some Cultural Experiments with Kenaf in Cuba," U. S. Department of Agriculture Circular No. 854, July, 1950.
6. Pate, J. B., Seale, C. C., and Gangstad, E. O., *Agron. J.* 46, No. 2: 75–77 (Feb., 1954).

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The Application of Probability Theory to Papermaking

O. J. KALLMES

The physical properties of paper cannot be related to one another because the internal structure of paper was not studied until recently. Using probability theory, it is possible to describe the structure of a model sheet composed of a pile of thin sheets; the properties of the model sheet and paper differ only slightly. This discussion points out the considerations used in developing a theory of paper structure, the type of information obtainable from the theory, and the approach to be used in an attempt to interrelate all paper properties.

There are in the paper industry, at present, a large number of tests designed to measure a relatively small number of physical properties of paper. Although each test is reproducible and, in conjunction with other tests, qualitatively accounts for the effects of process variables on paper properties, there are, to the best of my knowledge, no two tests directly related to each other through the properties of the fibers. Thus, it is impossible to calculate any sheet property directly from a knowledge of the fiber properties and the sheet-forming process.

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The lack of interrelationships among paper properties is not due to a lack of realization of what the determining parameters are (*1, 2*). It has been appreciated for some time that a knowledge of the fiber properties, the arrangement of the fibers of a sheet, i.e., its geometry or structure, and the strength of the bonds holding the fibers together ought to suffice to predict all the properties of a sheet. Unfortunately, only few direct studies have been made in these areas (*3–6*). In this discussion, we will show where probability theory can be used to describe paper structure and how the theory might be applied to interrelate the properties of a sheet. The other two parameters, the characteristics of fibers and of fiber-to-fiber contacts, are physical properties outside the scope of this discussion.

In studying the behavior of structures *per se*, the arrangement of the elements—all of which are considered to be homogeneous—is invariably considered first. Thus, the study of the strength of materials is always, to a large extent, an exercise in geometry. For example, in a detailed analysis of the behavior of a bridge, it would be unthinkable to consider it as

Fig. 1. Sheet of unbeaten spruce sulfite fibers, 10 g.s.m.

Fig. 2. Cross-section of kraft board

a simple beam supported at both ends. Yet, this generalization of homogeneity is normally made in paper testing in spite of the fact that most papers, when viewed under a high quality microscope, resemble the girder-like structure of a bridge in many ways (see Fig. 1).

PAPERMAKING AS A RANDOM PROCESS

The more or less uniform appearance of paper and the difficulties involved in visualizing and measuring the fiber arrangement are the probable reasons for the lack of knowledge of paper structure. One approach to the solution of the problem is by the use of probability theory in a careful analysis of the papermaking process.

Basically, papermaking is the assembly of fibers into a sheet by a process which does not in any way control the deposition of the individual fibers. It is generally desired that the sheet be uniform throughout, or as nearly so as possible. However, a process in which the individual elements are not carefully assembled cannot possibly give a uniform product. Thus, nonuniformity is an inherent property of randomly formed fiber networks, and a knowledge of this heterogeneity is essential to obtain an understanding of the behavior of paper.

In producing a sheet which is as uniform as possible, the papermaker strives to obtain a uniform headbox suspension by a violent pre-agitation. Because the suspension is extremely dilute, the fibers in it move about independently or in small groups, and their arrangement tends toward a *haphazardly formed* or *random* distribution. (It would approach true randomness at infinite dilution.) When the random fiber suspension hits the wire, every point on it has the same chance of being covered by the same number of fibers. These conditions of machine operation more or less fulfill the definition of a random process. The field of mathematics dealing with random processes is probability theory. Before discussing the information on paper structure which can be obtained from this theory, the effects of the other parts of the paper machine on the fiber arrangement must be considered.

In the headbox, the arrangement and orientation of the fibers is random in three dimensions. As the water is drained from the suspension on the wire, the compacting forces of the table rolls, suction boxes, and couch roll tend to give the fibers a preferred orientation toward the plane of the sheet. This tendency is greatly enhanced by the press section, possibly also by the surface tension forces of drying, and by calendering. Thus, in the majority of papers, the fibers lie almost entirely in planes parallel to the plane of the sheet, as is clear from the photomicrograph of a cross-section of kraft board (see Fig. 2). Therefore, in an idealized model of paper, any orientation of the fibers out of the plane of the sheet can be neglected.

(Under certain machine conditions, a sheet can be formed with a preferred fiber orientation in a particular direction within the plane of the sheet. As our studies have been confined to the most ideal papers with the simplest structure, considerations of this process variable have been omitted from this discussion except to mention that it can be taken into account.)

Although the fibers of most papers have a primarily planar orientation, paper is not two-dimensional as it has thickness. This thickness in part represents the real dimensions of the fibers and is also, in part, the result of the overlapping of fibers; obviously two fibers in contact cannot lie in the same plane. If a sheet is considered to be made of layers, each one fiber in thickness, its fibers would appear to weave in and out of two or more planes, i.e., the fibers would have an irregular, wavy appearance (see Fig. 2).

DEFINITION OF SHEET MODEL

In applying probability theory to describe the structure of paper, a relatively simple fiber shape must be assumed; the inclusion of irregularities in the shape of the fibers would hopelessly complicate the problem at the outset. The simplest model that can be used is a random network of finite straight lines of no width or thickness, lying in a single plane. This model applies reasonably well to a sheet containing very few fibers, but it becomes inapplicable when their number becomes large. These considerations led Corte and Kallmes (*4*) to the concept of a sheet composed of layers, i.e., a multiplanar (MP) sheet, each layer of which is so thin that its fibers lie essentially in a single plane. We called these ultrathin layers two-dimensional (2-D) sheets; 2-D sheets are not planar at the fiber-to-fiber

contacts only. However, as the contacts occupy only a small fraction of the sheet area, the deviation of 2-D sheets from a single plane can be neglected.

The use of MP sheets to describe paper has two other important characteristics: (1) the constituent 2-D layers are so thin that their individual fibers are clearly visible (see Fig. 3). This makes it possible to appreciate clearly the nature of the problem and to check experimentally theories of the structure of 2-D sheets. (2) 2-D sheets can be prepared in the laboratory and piled up into MP sheets of any thickness. Thus, the model used in the approach can be readily produced in the laboratory. A comparison of some properties of MP sheets and regularly formed handsheets of the same basis weight has shown that differences between the two are relatively small, less than 10% (7).

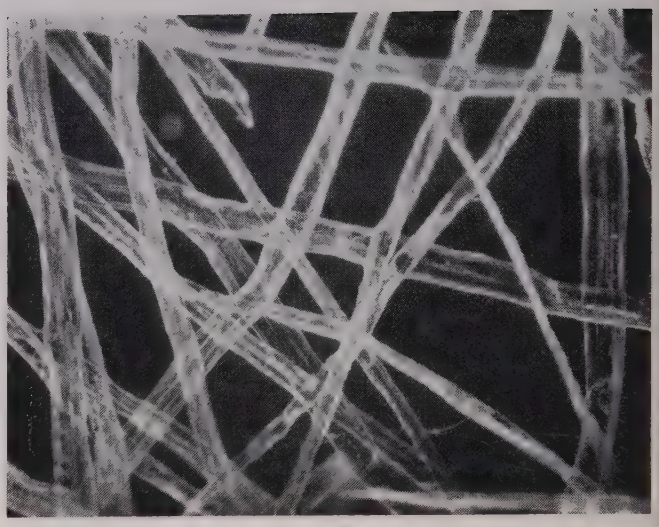

Fig. 3. 2-D Sheet of unbeaten spruce sulfite fibers

STRUCTRUAL PROPERTIES IMPORTANT TO BEHAVIOR PROPERTIES

In order to interrelate the various properties of paper, the theory of its structure must relate the geometric properties which give it its mechanical, porous, and optical properties directly to the properties of the fibers, the fiber-to-fiber contacts, and the sheet-forming process (in this discussion, a truly random process). These geometric properties of paper can be readily visualized from Fig. 3.

The mechanical properties of a sheet, i.e., its ability to resist an applied load and to deform, are a function of the stress–strain properties of the fibers and the fiber-to-fiber contacts and of *at least* five geometric properties. The strength of a sheet depends on: (1) the total number of fiber-to-fiber contacts, (2) the size of the bonded area of the fiber-to-fiber contacts, and (3) the number of contacts holding each fiber in the network. The ability of a sheet to deform depends on (4) the distance along a fiber between contacts, which we have called the *free fiber length*, and (5) the number of free fiber lengths in a sheet. It has been shown (7) that bending of the free fiber lengths is primarily responsible for the stretching of a sheet in the elastic zone, and this phenomenon, accompanied by the rupture of many fiber-to-fiber contacts (in ordinary paper, also the rupture of fibers), are the events occurring in the plastic zone.

The porous properties of a sheet depend on the number, size, and shape of its holes or pores. The pores of a 2-D sheet are irregular polygons (see Fig. 3); the pores of an MP sheet are the interconnected polygons of the 2-D layers. The optical properties of a sheet are a function of the light-absorbing mass and light-scattering surfaces of the fibers, i.e., the cellulose–air interfaces. The cellulose–air interfaces consist of the unbonded internal and external fiber surfaces, the latter being directly related to the number and mean area of the fiber-to-fiber contacts.

It is apparent from Fig. 3 that the geometric properties listed above vary over the sheet and from fiber to fiber. If the sheet is divided into small equal areas, say squares, distributions such as the mass or number of fiber-to-fiber contacts per unit area can be defined. Geometric properties of the individual fibers such as the number of fiber contacts and number of free fiber lengths per fiber have distributions. In fact, every geometric property has a distribution, and these distributions must be included in a complete description of the structure of a sheet.

Corte and Kallmes used probability theory to derive equations for the distributions and means of the geometric properties of a randomly formed 2-D fiber network (4). The theory has been extended to MP sheets and these findings will be published shortly. In all of this work, it turned out that the problems could be solved from basic probability theory, either directly or after making certain simplifying assumptions; sophisticated theories are not available at present for some of the more difficult problems. Thus, all of the equations were not derived rigorously, and some of the distributions obtained are, at best, only good approximations.

It was possible to reduce all of the equations describing the geometric properties of 2-D sheets to fiber properties and sheet-forming properties. In other words, the structure of an ideal, random 2-D or MP sheet is completely described by the statement that it contains N fibers of known length, width, thickness, and curl formed into a sheet of area A by a random process. Further details of the structure of a sheet can be evaluated from the derived equations, but these equations are only special forms of the italicized statement.

APPLICATION OF PROBABILITY THEORY

Before going into the approach in which probability theory might be applied in interrelating the behavior properties of a sheet, one geometric property of 2-D and MP sheets will be mentioned. It was found that the *total number* of fiber-to-fiber contacts depends only on the *total length* of fibrous material in a sheet and the fiber width and flexibility; i.e., it is independent of fiber length. Thus, changing the fiber length, i.e., fiber cutting, does not affect the total number of contacts in a sheet but only decreases the number of contacts per fiber. If it is assumed that fiber cutting does not affect the bonded area of fiber-to-fiber contacts, it can be concluded that changes in strength properties caused by fiber cutting are not the result of a change in the total bonded area of a sheet, but due to a decrease in the bonded area per fiber.

It should be possible to work out the mechanical properties of MP sheets now that their structure is known. This is the next step of these studies and probably a much more difficult one than the problem of structure. Our approach to it will be the same as in the case of structure; i.e., we are beginning with a study of the mechanical properties of 2-D sheets. These sheets contain the same elements as MP sheets and ordinary paper, only fewer of them. Thus, the phenomena caused by straining 2-D and MP sheets ought to be similar, except that in the case of the 2-D sheets they will be plainly visible and greatly exaggerated. From observing the straining of 2-D sheets, it should be possible to define the problem precisely.

Probability theory will be applied to classical mechanics in a similar manner as in the case of structure. We hope to answer such questions as how much 2-D and MP sheets stretch before the first fiber-to-fiber contacts are ruptured (the extent of the elastic zone), how the structure of the sheets changes as contacts and fibers are severed (the plastic zone), which contacts are broken (i.e., the characteristics of the free fiber lengths affected), and how many contacts are ruptured before the sheet is completely torn. An excellent beginning along these lines has been made by Litt (*8*), who related the mechanical properties of fibers to the elastic properties of paper quantitatively and to their plastic properties qualitatively without using sheet structure directly. As a first step, this work will be repeated applying sheet structure directly.

There is, of course, no guarantee that the approach we have chosen to interrelate the various properties of paper will be successful. However, on the basis of preliminary findings only, we are certain to learn much of the behavior of paper generally.

LITERATURE CITED

1. Van den Akker, J. A., *Tappi* 33, No. 8: 398–402 (Aug., 1950).
2. Meredith, R., "Mechanical Properties of Wood and Paper," Part B. Amsterdam, North Holland Publishing Co., 1953.
3. Jayne, B. H., *Forest Products J.* 10, No. 6: 316–322 (June, 1960).
4. Kallmes, O. and Corte, H., *Tappi* 43, No. 9: 737–752 (Sept., 1960).
5. Page, D. H., *Paper Technology* 1, No. 4: 407–411 (Aug., 1960).
6. Page, D. H. and Tydeman, P. A., *Paper Technology* 1, No. 5: 519–530 (Oct., 1960).
7. Corte, H. and Kallmes, O., "The Elastic Properties of Multiplanar Sheets," To be presented at Symposium on the Formation and Structure of Paper, September, 1961.
8. Litt, M., *J. Colloid Science*, in press.

Received Feb. 27, 1961. Presented at the 46th Annual Meeting of the Technical Association of the Pulp and Paper Industry, held in New York, N. Y., Feb. 20–23, 1961.

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The Structure of Paper

II. The Statistical Geometry of a Multiplanar Fiber Network

O. KALLMES, H. CORTE, and G. BERNIER

The theory of the structure of multiplanar (MP) sheets, which consist of piled-up ultra-thin (2-D) sheets, is presented. It is shown that the properties of MP and equivalent, normally formed handsheets of spruce pulps are not significantly different. Thus, the theory is applicable to handsheets of softwood fibers. The main value of the theory is that quantitative theories of paper behavior can be based on it; a theory of the elasticity of paper will be published soon. In the present article, it is shown that the elastic modulus, and the breaking load and stretch are linearly related to the mean number of fibers holding each fiber in the network, $\bar{c}_m$. These results suggest that $\bar{c}_m$ is a fundamental parameter through which paper and fiber properties can be interrelated. Thus, the theory of MP sheet structure is possibly a basis for a science of paper. Methods of calculating the maximum values of paper properties are presented.

The structure of paper, defined and partially described in (*1*), is developed further in this article. In (*1*) the structure of paper was defined to be the geometric arrangement of the fibers and interfiber spaces or pores. Because of its complexity, we approached the problem by considering paper to be made of a pile of ultra-thin or two-dimensional (2-D) sheets. The geometry of a 2-D sheet was reported in (*1*); the geometry of a pile of 2-D sheets, a multiplanar (MP) sheet, is presented in this article. A comparison of the properties of MP and equivalent, normally formed sheets is also given.

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The same basic considerations have been applied to MP sheets as to 2-D sheets; they are presented in the sections Statement of the Problem and Mathematical Basis of (*1*). The same symbols are used as in (*1*), except that a prime has been added to the symbols representing the properties of sheets made from fibers of no width, and the subscript m to the symbols representing the properties of MP sheets.

NOMENCLATURE

A	= area of sheet, sq. cm.
B	= correction factor for fiber width
C	= constant $= \sigma_K/p(0)^{K-2}$
$\bar{c}'$	= mean number of crossings per fiber of no width in one 2-D layer
$\bar{c}_K$	= mean number of crossings per fiber in Kth layer
$\bar{c}_{Ki}$	= mean number of crossings per fiber of length i in Kth layer
$n^*(c_K)$	= frequency of fibers with c_K crossings
$\bar{c}_m$	= mean number of crossings per fiber in an MP sheet
$\bar{g}_K$	= mean free fiber length in Kth layer, cm.
$r^*(g_K)$	= frequency of free fiber lengths with lengths between g_K and $g_K + dg_K$
$\bar{g}_m$	= mean free fiber length of MP sheet, cm.
K	= number of a specific layer in sheet
$\bar{m}_m$	= mean length of fibrous material in 1 sq. mm. of an MP sheet, cm.
$l^*(\bar{m}_m)$	= frequency of 1-sq.-mm. squares with total length of fibrous material between $\bar{m}_m$ and $\bar{m}_m + d\bar{m}_m$
N_c'	= number of crossings of fibers of no width in one 2-D layer of area A
N_{cm}	= number of crossings in MP sheet of area A
N_f	= number of fibers in a 2-D layer of area A
N_f'	= number of fibers of no width in one 2-D layer of area A
N_{fm}	= number of fibers in MP sheet of area A
$\bar{n}_{gK}$	= mean number of free fiber lengths per fiber in Kth layer

$n^*(n_{gK})$ = frequency of fibers with n_{gK} free fiber lengths
$\bar{n}_{gm}$ = mean number of free fiber lengths per fiber in MP sheet
N_L = number of layers in MP sheet
$\bar{n}_{seg}$ = mean number of fiber segments per sq. mm. of one 2-D layer
$\bar{n}_{seg\ m}$ = mean number of fiber segments per sq. mm. of MP sheet
$p(\bar{n}_{seg\ m})$ = frequency of 1-sq.-mm. squares containing between $n_{seg\ m}$ and $n_{seg\ m} + dn_{seg\ m}$ segments
P = probability of an intersection between two real fibers
P' = probability of an intersection between two fibers of no width
$p(0)$ = fractional uncovered area of a 2-D layer
R = width of sheet, cm.
S = fractional stretch at breaking load
T = breaking load, g.
U = constant
V = constant
W = basis weight of sheet, g./sq. cm.
$\bar{w}$ = specific fiber weight, g./cm. of length
Y = elastic modulus of sheet, g./cm.
$\bar{\delta}$ = fiber thickness, cm.
$\bar{\lambda}$ = fiber length, cm.
$\phi(\lambda_i)$ = frequency of fibers in ith length class
λ_{seg} = fiber segment length, cm.
σ_f = intrinsic fiber flexibility
σ_K = effective fiber flexibility
$\bar{\tau}$ = fiber curl factor
$\bar{\omega}$ = fiber width, cm.

DEFINITION OF AN MP SHEET

An MP sheet consists of a pile of N_L 2-D sheets [defined in (*1*)]. As in the case of 2-D sheets, many of the geometric properties of interest to the papermaker can be found from the total number of fiber-to-fiber contacts (crossings) in the sheet. The number of crossings in an MP sheet is the sum of the number of crossings *within* the 2-D layers and the number *between* the layers. The former is found from equation (5) of (*1*); the latter depends on the number of crossings the fibers of each layer make with the fibers of all of the other layers. The number of interlayer crossings is a function of the flexibility of the fibers and such process variables as the pressure applied during pressing and drying. All such variables can be taken into account in the theory giving the number of crossings in an MP sheet.

An MP sheet is a model for paper and, as such, it differs from normally formed paper in three ways:

1. The fibers of an MP sheet have no *Z*-direction orientation, i.e., out of the plane of the sheet. However, it is obvious from photomicrographs of cross sections of papers that the *Z*-direction orientation is negligible and can be neglected (see Fig. 1).
2. The fibers of MP sheets lie in definite planes.
3. There is no interweaving of the fibers among the layers of MP sheets; this feature is the biggest difference between the MP model and real paper. It would invalidate the approach if effects due to, or due to the lack of, interweaving caused MP sheets and paper to behave in an appreciably different manner. However, it has been found experimentally that such phenomena are of minor importance and that the properties of MP and normally formed sheets are only slightly different.

The approach using the MP model to paper has one important advantage over the more general three-dimensional mathematical analysis of paper structure. In the latter case, a definite cross-sectional shape must be assigned to fibers randomly placed, as lines of no width or thickness make no intersections (in space). The nature of the cross-sectional shape has a great effect on the predicted number of fiber crossings. One could assign various shapes to fibers such as circular, elliptical, or rectangular. However, the fibers of every pulp have a wide variety of natural shapes and often assume different and highly complex ones in dried paper. This factor makes the application of the general three-dimensional approach to *real paper* hopelessly complex at the outset. On the other hand, the fiber shape is of minor importance in the theory of the structure of MP sheets and it can be incorporated relatively easily.

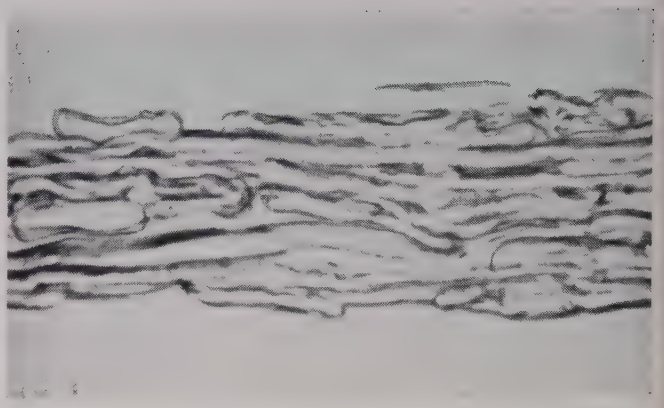


Fig. 1. Cross-section of 20-g.s.m. spruce sulfite sheet. Magnification 500×

EQUATIONS FOR THE OVERALL AND AVERAGE VALUES OF THE PROPERTIES OF AN MP SHEET

The equations for the overall and average values of the geometric properties of an MP sheet are based on the properties of an ideal 2-D sheet. As in the case of 2-D sheets, these equations can be written in terms of the independent fiber and sheet properties: the mean fiber length, $\bar{\lambda}$, width, $\bar{\omega}$, thickness, $\bar{\delta}$, planar curl factor, $\bar{\tau}$, effective fiber flexibility, σ_K, and specific fiber weight, $\bar{w}$; the number of fibers in the sheet, N_{fm}; and the basis weight, W, and area, A, of the sheet.

Total Number of Fiber Crossings

Consider N_L 2-D sheets, each containing N_f' fibers and N_c' crossings, piled on top of one another. (Throughout this article the primes refer to fibers of no width.) If the fibers of every layer make all possible contacts with the fibers of every other layer, we have the case of projecting $N_f'N_L$ fibers onto a plane, i.e., the case of the 2-D sheet. The number of crossings formed is (*1*):

$$\frac{(N_f'N_L\bar{\lambda})^2}{\pi A\bar{\tau}^2} = N_c'N_L^2 \qquad (1)$$

Consider next the case of relatively rigid fibers of no width in contact only with fibers of their own layer and those of the two contiguous layers. The number of crossings *within* the N_L layers is N_LN_c'. The number of crossings *between* a pair of contiguous layers is:

$$N_f'\bar{c}' = 2N_c' \qquad (2)$$

where $\bar{c}'$ is the number of crossings a fiber makes with the fibers of *one* 2-D layer. (It was shown in (*1*) that $\bar{c}' = 2N_c'/N_f'$.) The total number of crossings in an MP sheet of this type is:

$$N_LN_c' + (N_L - 1)2N_c' = N_c'(3N_L - 2) \qquad (3)$$

The number of crossings in an MP sheet of real

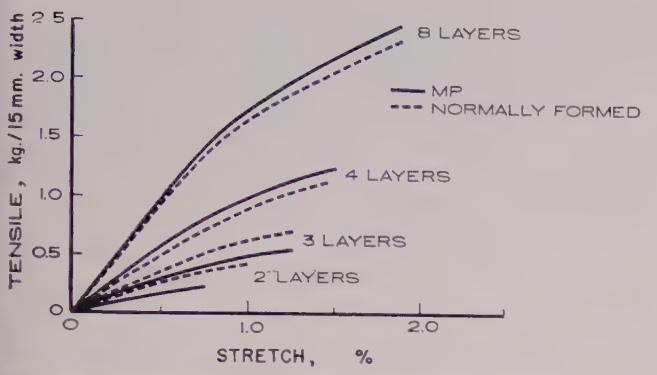


Fig. 2a. Stress–strain curves of MP and equivalent normally formed sheets
Sulfite pulp—1000 p.s.i. pressure

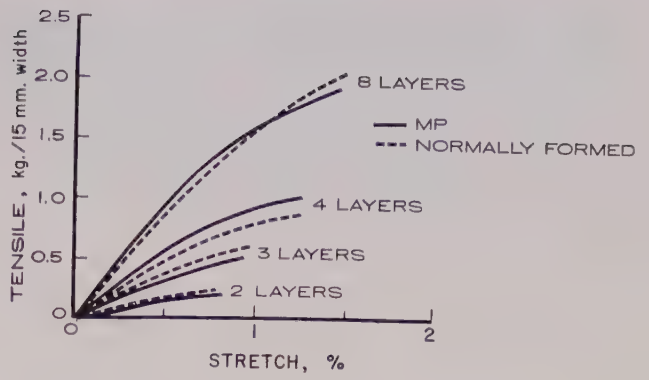


Fig. 2b. Stress–strain curves of MP and equivalent normally formed sheets
Sulfite pulp—50 p.s.i. pressure

fibers is somewhere between the two extreme cases described by equations (1) and (3). Its value depends on the *fraction of the number of possible contacts actually made between the fibers of every possible pair of layers which can be chosen,* a fraction which we have defined to be the "effective fiber flexibility," σ_K. (The subscript refers to the relative position of a layer to the one under consideration.) The effective fiber flexibility is a function of the following factors:

1. The intrinsic fiber flexibility σ_f. σ_f is a true fiber property which should be affected by every phase of pulping and mechanical treatment.
2. The number of layers between the two layers under consideration. Obviously, σ_K will be smaller, the greater the number of layers between the pair.
3. The degree of wet pressing and the amount of pressing applied during drying. Most likely, σ_K will become larger as the amount of pressure applied during these processes is increased.

In the present article, we have not considered extensively how the various processes, i.e., pulping, beating, pressing, etc., affect σ_K because the evaluation of these variables is a separate study; we have used the "effective fiber flexibility" throughout.

The number of crossings formed in a 2-D and in an MP sheet by real fibers also depends on the fiber width, a factor not taken into consideration in (*1*). It was shown in (*1*) that the probability that a pair of randomly placed fibers of no width intersects within a plane of area A is:

$$P' = \frac{2\bar{\lambda}^2}{\pi A \bar{\tau}^2}$$

However, the probability of an intersection between a pair of fibers of width $\bar{\omega}$ is less than P' because a fraction $[1 - p(0)]$ of a 2-D layer is covered by other fibers [$p(0)$ is the fractional open area of a 2-D layer and is equal to $exp(-N_f\bar{\lambda}\bar{\omega}/A)$ (*1*)]. However, P' is only reduced by the factor $^1/_2\,[1 - p(0)]$ because in half of the cases where the two given fibers are in contact with other fibers, the other fibers are behind the given fibers and do not prevent the formation of a fiber-to-fiber contact. Thus, the probability that a given pair of real fiber make a crossing in a 2-D sheet is:

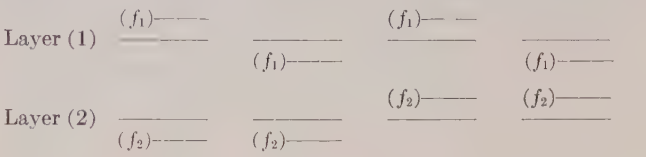
$$P = P'[1 - {}^1/_2\{1 - p(0)\}] = P'\{{}^1/_2[1 + p(0)]\} = P'B \quad (4)$$

Using similar considerations, equation (1) becomes:

$${}^1/_2 N_c' N_L{}^2[1 + exp\,(-N_L N_f \bar{\lambda}\bar{\omega}/A)] \quad (5)$$

The correction for fiber width for crossings between fibers of contiguous layers is found as follows:

Consider the ways in which a given fiber (f_1) of layer (1) can make a contact with a given fiber (f_2) of layer (2) (see below). There are four possibilities, each with a probability of $^1/_4$.



$$^1/_4 P'p(0)^2 + {}^1/_4 P'p(0) + {}^1/_4 P'p(0) + {}^1/_4 P' = P'B^2.$$

Thus, equation (3) becomes:

$$N_c' N_L B + 2N_c' B^2(N_L - 1) = N_c' B[N_L + 2B(N_L - 1)] \quad (6)$$

For the case of MP sheets formed by real fibers, it was found experimentally that the effective fiber flexibility has one value for fibers within a layer, σ_1, a second value for fibers between contiguous layers, σ_2, and a set of values for fibers between layers separated by one or more other layers, $\sigma_{\geq 3}$. It was found experimentally that the number of crossings between layers separated one layer, i.e., due to σ_3, is relatively small, and that the contributions due to the $\sigma_{>3}$'s are negligible. Therefore, it is reasonable to set $\sigma_{\geq K \geq 3}/p(0)^{K-2} =$ constant $= C$, a step which greatly simplifies the mathematics (the Kth layer is separated from a given layer by $K - 2$ other layers). Introducing the effective fiber flexibilities appropriately and summing up the fiber crossings between all pairs of layers gives the total number of fiber crossings in an MP sheet, N_{cm}, or:

$$N_{cm} = N_c' N_L B \left\{ \sigma_1 + 2B\left[1 - \frac{1}{N_L}\right]\left[\sigma_2 + \frac{Cp(0)^2}{1 - p(0)^2}\right] - \frac{2Cp(0)^2[1 - p(0)^{2(N_L-1)}]}{N_L[1 - p(0)^2]^2} \right\} \quad (7)$$

(The derivation of equation (7) is in Appendix I.)

For the case of fibers of no width making perfect contact with each other, i.e., $p(0) = 1$, and σ_1, σ_2, $\sigma_3 = 1$, equation (7) reduces to expression (1); for the case of relatively rigid fibers of no width only in contact with fibers of their own layer and contiguous layers, i.e., $p(0) = 1$, σ_1, $\sigma_2 = 1$, and $\sigma_3 = 0$, it reduces to expression (3).

Mean Number of Crossings per Fiber

The mean number of crossings per fiber in an MP sheet, $\bar{c}_m$, is:

$$\bar{c}_m = \frac{2N_{cm}}{N_f N_L} \quad (8)$$

where N_{cm} is found from equation (7). However, the number of crossings per fiber is not the same for all of the layers of an MP sheet; it is a minimum for the edge layers which are only in contact with layers on one side and a maximum for the central layer or layers. It is shown in Appendix II that the mean number of crossings per fiber of the fibers of the Kth layer, if $K \leqslant 2 \leqslant N_L - 1$, is:

$$\bar{c}_K = \bar{c}'B \left\{ \sigma_1/2 + B \left[2\sigma_2 + \frac{Cp(0)^2}{1 - p(0)^2} \left(2 - p(0)^{2(N_L - K - 1)} - p(0)^{2(K-2)} \right) \right] \right\} \quad (9)$$

and for the edge layers:

$$\bar{c}_1 = \bar{c}'B \left\{ \sigma_1/2 + B \left[\sigma_2 + \frac{Cp(0)^2}{1 - p(0)^2} \left(1 - p(0)^{2(N_L - 2)} \right) \right] \right\} \quad (9a)$$

As B, σ_1 and σ_2 are relatively large fractions and $Cp(0)^2$ is a relatively small fraction (see Experimental Program), the first two parts of equation (9) (involving σ_1 and σ_2) are much greater than the third (σ_3). Thus, for $K \geqslant 3$, $\bar{c}_i/\bar{c}_j \sim 1$.

The ratio of $\bar{c}_1/\bar{c}_{K \geqslant 3}$ is approximately 3:5. This ratio can be readily deduced from the case of the crossings of relatively rigid fibers in contact only with fibers of their own layer and those of the contiguous layers, equation (3). The number of crossings involving the fibers of each edge layer is $N_c' + 2N_c' = 3N_c'$ [see equation (2)]; the number of crossings involving the fibers of the central layers is $N_c' + 2(2N_c') = 5N_c'$. Thus, the ratio of the number of crossings per fiber of the edge to the central layers is 3:5.

Mean Number of Free Fiber Lengths per Fiber and Mean Free Fiber Length

The mean number of free fiber lengths per fiber, $\bar{n}_{gm}$, is determined in the same manner as in the case of 2-D sheets [see equation (A10) of (*1*)]. Thus:

$$\bar{n}_{gm} = \bar{c}_m \left[1 - \frac{\pi\bar{\omega}\bar{\tau}}{2\bar{\lambda}} \right]^{\bar{c}_m} \quad (10)$$

The mean free fiber length, $\bar{g}_m$, is also found in the same manner as in the case of 2-D sheets [see equation (8) of (*1*)]. Thus:

$$\bar{g}_m = \frac{\bar{\lambda}}{\bar{c}_m\bar{\tau}} \quad (11)$$

[It should be noted that the fiber width does not affect $\bar{g}_m$ (*1*).]

Because $\bar{n}_{gm}$ and $\bar{g}_m$ are, respectively, directly and inversely proportional to $\bar{c}_m$, the numerical values of $\bar{n}_{gK}$ and $\bar{g}_K$ vary from the edge to the central layers. Thus, there are fewer but longer free fiber lengths in the edge layers than in the central layers. The equations for $\bar{n}_{gK}$ and $\bar{g}_K$ for the Kth layer of an MP sheet are found as follows:

It was shown in (*1*) that the mean free fiber length depends only on the number of crossings per fiber and is independent of the fiber width. For the Kth layer of an MP sheet, the mean free fiber length, $\bar{g}_K$, is equal to $(\bar{\lambda}/\bar{\tau})$, divided by $\bar{c}'\sigma_1 B$ plus the number of contacts per fiber between fibers of the Kth layers and the other layers of the sheet [see equations (A4) and (A6) in Appendix I], only if $2 \leqslant K \leqslant N_L - 1$, or:

$$\bar{g}_K = \frac{(\bar{\lambda}/\bar{\tau})}{\bar{c}'B \left\{ \sigma_1/2 + B \left[2\sigma_2 + \frac{Cp(0)^2}{1 - p(0)^2} \left(2 - p(0)^{2(N_L - K - 1)} - p(0)^{2(K-1)} \right) \right] \right\}} \quad (12)$$

and for the edge layers:

$$\bar{g}_1 = \frac{(\bar{\lambda}/\bar{\tau})}{\bar{c}'B \left\{ \sigma_1/2 + B \left[\sigma_2 + \frac{Cp(0)^2}{(1 - p(0)^2} \left(1 - p(0)^{2(N_L - 2)} \right) \right] \right\}} \quad (12a)$$

The mean number of free fiber lengths per fiber of the fibers in the Kth layer, $\bar{n}_{gK}$, is:

$$\bar{n}_{gK} = \frac{\bar{\lambda}}{\bar{\tau}\bar{g}_K} \left[1 - \frac{\pi\bar{\omega}\bar{\tau}}{2\bar{\lambda}} \right]^{\frac{\bar{\lambda}}{\bar{\tau}\bar{g}_K}} \quad (13)$$

DISTRIBUTION OF PROPERTIES OF AN IDEAL MP SHEET

The distributions of the geometric properties of an ideal MP sheet must be based on the same assumptions and derived by the same techniques as those of a 2-D sheet (*1*). As in the case of 2-D sheets, it was not possible to overcome certain basic mathematical difficulties, and some approximations and simplifications had to be made. Two types of distributions are given, areal distributions which show the variations of geometric properties among the 1-sq.-mm. squares,* and frequency distributions, which describe the variations over individual geometric elements, i.e., the fibers.

Areal Distribution of Mean Length or Mass of Fibrous Material per Square Millimeter

The only areal distribution described is the distribution of the mean length or mass of fibrous material per square millimeter. It is based on the differential form of the Poisson distribution for the number of fiber segments per square millimeter (*1*).

$$p(n_{\text{seg } m}) = \frac{[exp\,(-\bar{n}_{\text{seg } m})]\bar{n}_{\text{seg } m}{}^{n_{\text{seg } m}}}{(n_{\text{seg } m})!}\, dn_{\text{seg } m} \quad (14)$$

where $p(n_{\text{seg } m})$ is the fraction of 1-sq.mm. squares of an MP sheet containing between $n_{\text{seg } m}$ and $n_{\text{seg } m} + dn_{\text{seg } m}$ segments; $n_{\text{seg } m} = N_L n_{\text{seg}}$; and n_{seg} is the number of segments in 1 sq. mm. of a 2-D layer. It will be recalled from (*1*) that a fiber segment is the portion of a fiber within a 1-sq. mm. square.

Although the mass per millimeter of fiber length varies from fiber to fiber, particularly between springwood and summerwood fibers, this distribution has not been taken into account and the mean mass per millimeter of fiber length, the specific fiber weight, $\bar{w}$, is used. As this simplification leads to identical equations for the length and mass distributions, the symbol $\bar{m}_m$ denotes the mean length or mass of fibrous material per square millimeter.

Equation (14) is transformed to the distribution of the mean length (or mass) of fibrous material per square millimeter by introducing the following substitutions:

$$\bar{m}_m = \bar{\lambda}_{\text{seg}} n_{\text{seg } m} \quad (15)$$

$$d\bar{m}_m = \bar{\lambda}_{\text{seg}} dn_{\text{seg } m} \quad (15a)$$

* The sheet is divided into 1-sq.-mm. squares for this part of the investigation. This size of square has no fundamental significance but was chosen for two reasons: (1) it is of the same order of magnitude as the basic structural unit of paper, the fiber, and (2) it is the smallest area in which experiments can be carried out conveniently.

where $\bar{\lambda}_{seg}$ is the mean segment length. (In deriving an expression for the mass distribution, $\bar{w}$ would be used in equations (15) and (15a) instead of $\bar{\lambda}_{seg.}$)

Substituting equations (15) and (15a) into equation (14) gives the distribution of the mean length of fibrous material per square millimeter:

$$l^*(\bar{m}_m) = \frac{[exp\ (-\ \bar{n}_{seg\ m})]\bar{n}_{seg\ m}^{\ \bar{m}_m/\bar{\lambda}_{seg}}}{\bar{\lambda}_{seg}\left[\frac{\bar{m}_m}{\bar{\lambda}_{seg}}\right]!}\, d\bar{m}_m \qquad (16)$$

where $l^*(\bar{m}_m)$ is the fraction of 1-sq.-mm. squares containing a mean length of fibrous material between $\bar{m}_m$ and $\bar{m}_m + d\bar{m}_m$.

The equations for $\bar{\lambda}_{seg}$ and $\bar{n}_{seg}$ were derived in (*1*) in terms of the independent fiber and sheet properties. They are as follows:

$$\bar{\lambda}_{seg} = \frac{\bar{\lambda}\bar{\tau}^2\pi}{4\bar{\lambda} + \pi} \qquad (17)$$

$$\bar{n}_{seg} = \frac{\bar{n}_f(4\bar{\lambda} + \pi)}{\pi\bar{\tau}^2} \qquad (18)$$

The distribution of the mean number of crossings per square millimeter is an areal distribution which could be derived by the same techniques as equation (16). The distribution of the number of segments per square millimeter of the entire MP sheet [equation (14)], and the distribution of the number of segments per square millimeter 2-D layer within each 1 sq. mm. of the sheet would have to be considered. Although this can be readily done and an areal distribution of the mean number of crossings per square millimeter can be derived from the result, the final expression is only an approximation, extremely complicated, impossible to verify, and of little foreseeable use. For these reasons, this distribution is not given here.

Frequency Distributions

The frequency distributions are concerned with the properties of the individual elements, i.e., the fibers. The frequency distributions considered include: (1) the number of fiber crossings per fiber, (2) the number of free fiber lengths per fiber, and (3) the size distribution of the free fiber lengths.

The frequency distributions are the same as those of a 2-D sheet. However, the numerical values vary from layer to layer because the mean number of crossings per fiber in a given layer increases from the edge to the central layers (see section on means of geometric properties).

1. Distribution of Number of Crossings per Fiber of Fibers in the Kth Layer

$$n^*(c_K) = \sum_{i=1}^{\infty} \frac{[exp(-\ \bar{c}_{Ki})]\bar{c}_{Ki}^{\ c_K}}{c_K!}\, \phi(\lambda_i) \qquad (19)$$

where $n^*(c_K)$ is the fraction of all fibers of the Kth layer crossed by c_K fibers, $\bar{c}_{Ki}$ is the mean number of crossings per fiber in the Kth layer of the ith fiber length class, and $\phi(\lambda_i)$ is the frequency of the fibers of the ith fiber length class.

2. Distribution of Number of Free Fiber Lengths per Fiber of Fibers in the Kth Layer

$$n^*(n_{gK}) = \sum_{i=1}^{\infty} \frac{[exp(-\ \bar{c}_{Ki})]\bar{c}_{Ki}^{\ -n_{gK}\Big/\left(1-\frac{\pi\bar{\omega}\bar{\tau}}{2\bar{\lambda}}\right)^{\bar{c}_K}}}{\left(1-\frac{\pi\bar{\omega}\bar{\tau}}{2\bar{\lambda}}\right)^{\bar{c}_K}\left[n_{gK}\Big/\left(1-\frac{\pi\bar{\omega}\bar{\tau}}{2\bar{\lambda}}\right)^{\bar{c}_K}\right]!}\, \phi(\lambda_i)dn_{gK} \qquad (20)$$

where $n^*(n_{gK})$ is the fraction of the fibers of the Kth layer with n_{gK} free fiber lengths [see equations (24) and (A10) of (*1*)].

Distribution of Size of Free Fiber Lengths of Fibers in the Kth Layer

$$r^*(g_K) = \frac{\bar{\tau}\bar{c}_K}{\bar{\lambda}} exp\left[-\frac{\bar{\tau}\bar{c}_K}{\bar{\lambda}}\, g_K\right] dg_K \qquad (21)$$

where $r^*(g_K)$ is the probability that the distance between two crossings in the Kth layer lies between g_K and $g_K + dg_K$. It should be noted that the distribution of g_K is independent of the fiber width (*1*).

EXPERIMENTAL PROGRAM

The equations for the geometric properties of MP sheets cannot be checked directly because it is impossible to see fibers inside of a heavy sheet. However, an excellent verification will be obtained when the theory is applied to predict various properties of paper quantitatively. The first such application will be reported in (*2*) where the elasticity of MP sheets is related to their structure and to the mechanical properties of their fibers.

It should be noted that the parts of the equations for the within-layer properties were verified in (*1*) and that the parts for the between-layer properties are only extensions of the 2-D sheet theory. Thus, the equations for the properties of MP sheets have been partially verified.

The experimental program was designed to measure: (1) the fiber and sheet properties which must be known to evaluate the equations for $\bar{c}_m$, $\bar{g}_m$, $\bar{c}_K$ and $\bar{g}_K$ (probably the most important sheet properties and the only ones which can be readily visualized), (2) to compare some of the properties of MP and equivalent sheets, and (3) to demonstrate some of the possible applications of the theory of the MP sheet structure.

The following were measured: (1) the fiber dimensions (see Table I); (2) the properties of the 2-D layers of the sheets (see Table II); and (3) the effective fiber flexibilities (see Table III). The techniques for measuring (1) and (2) are described in (*1*); the σ_K's were measured on thin handsheets by the following procedure, which is based on the optical technique of Page and Tydeman (*3, 4*).

Three-layer sheets—top layer undyed, middle layer dyed with Congo red, and bottom layer dyed with methyl violet—were used. The 2-D layers were formed individually in a TAPPI handsheet mold, couched off onto one blotter, and pressed and dried together. The sheets were examined under polarized vertical illumination (Zeiss microscope, Model WL pol, epi II B pol, 690X). Under these conditions the fraction of the area in optical contact of almost all crossings can be measured. It is generally believed—and we agree with the concept—that interfiber bonding exists in the areas of optical contact.

The quantitative evaluation of the σ_K's was not possible on heavier sheets because of interference by diffuse scattering from the lower layers. Thus, it is assumed that the σ_K's obtained at a given pressure are independent of the basis weight of the sheet.

The crossings examined were those between randomly selected white fibers and undyed (σ_1), red (σ_2), and purple (σ_3) fibers. The degree of optical contact of

Table I. Fiber Properties

Pulp	Length ($\bar{\lambda}$), cm.	Width ($\bar{\omega}$), cm.	Thickness ($\bar{\delta}$), cm.	Curl factor (1) ($\bar{\tau}$)	Specific fiber weight,[b] $\bar{w}$, g./cm
Sulfite	0.22 (781)[a]	0.0037 (354)	2.73×10^{-4} (84)	1.07 (781)	1.3×10^{-6}
Kraft	0.21 (405)	0.0035 (273)	2.64 (273)	1.13 (405)	1.5

[a] Number of crossings examined.
[b] Obtained from scanning 120 cm. on three 2-D sheets (~15,000 fibers) (*1*).

every crossing was estimated to the nearest one quarter of the area. No differentiation was made among the three types of crossings defined in references (*3*) and (*4*).

The random selection of each undyed fiber was made by selecting the one whose tip was found first after completing the measurements on another fiber.

The evaluation of the σ_K's was made on two specially prepared unbeaten and unbleached spruce pulps, a sulfite and a kraft. The sulfite pulp was prepared with the following cooking liquor composition: 7.2% total SO_2, 1.3% combined SO_2 (calcium base); cooking time, 11 hr.; and maximum temperature, 130°C. maintained for 6 hr. The kraft pulp was prepared as follows: cooking liquor composition, 50 g.p.l. active alkali, 35% sulfidity; cooking time, $2^1/_2$ hr.; maximum

Table II. Fiber Flexibility

Pulp	Pressing pressure, p.s.i.	σ_1	σ_2	σ_3 at $p(0)$	C
Sulfite	1000	0.95 (190)[a]	0.89 (644)	0.64 at 0.43 (380)	1.49
	50	0.92 (346)	0.71 (424)	0.44 at 0.44 (281)	1.00
Kraft	1000	0.84 (416)	0.65 (518)	0.37 at 0.48 (269)	0.78
	50	0.74 (399)	0.51 (428)	0.27 at 0.52 (191)	0.54

[a] Number of crossings examined.

temperature, 168°C.; and hydrostatic pressure, 150 p.s.i. The pulps were not blown from the digester but manually removed. Prior to being formed into handsheets, they were treated by the procedure outlined in (*1*).

Two sets of handsheets were prepared for each pulp, one set pressed at 1000 p.s.i. for 2 min., and the other set at 50 p.s.i. for 5 min. (standard TAPPI conditions).

Using the data of Tables I, II, and III, the values of $\bar{c}_m$ and $\bar{g}_m$ and the values of $\bar{c}_K$ and $\bar{g}_K$ for every layer of 2-, 3-, 4-, 8-, and 12-layer MP sheets were calculated (see Tables IV and V). It was assumed in the calculations of $\bar{g}_m$ and $\bar{g}_K$ that the contact area of every crossing was 100% optically bonded. Preliminary measurements have shown that only 75 to 90% of the areas are in optical contact; this correction can be taken into account in the application of the structure theory.

The calculation of the $\bar{c}_K$'s and $\bar{g}_K$'s was repeated using values of $\sigma_K = 1$ (see Tables IV and V). The data obtained in this way are the maximum $\bar{c}_K$ and minimum $\bar{g}_K$ values for sheets of spruce fibers. These values would be obtained if the fibers were perfectly flexible, a condition which may be approached in highly beaten pulps. Thus, the data for the sheets whose fibers' σ_K's = 1 are listed as "hypothetical well-beaten pulps."

Four properties of MP and equivalent sheets were compared. These are (1) the specific volume, (2) the elastic modulus, (3) the breaking load, and (4) the breaking stretch. Each data point is the average measurement of six sheets, 3.0 cm. long, 1.5 cm. wide. In order to compare the sheets of different basis weights, the data were reduced to a unit mass basis (see Tables VI and VII and Figs. 2 and 3; the original data are given in Appendix III.)

DISCUSSION AND CONCLUSIONS

The principal value of the theory of the structure of MP sheets is that it presents, for the first time, a basis from which *quantitative* theories of paper behavior can be derived; the first such application, a theory of the elasticity of paper, will be presented in (*2*). The present discussion is concerned with some of the experimental results and with the possible applications of the structure theory.

As pointed out in the Definition of an MP Sheet, the structure theory is only of use if the differences between the properties of MP and equivalent sheets are so small that they can be neglected. Four factor analyses of variance were run on four sheet properties reduced to a unit mass; the specific volume, the elastic modulus, the breaking load, and the breaking stretch (see Tables VI and VII). The four variables studied included two process variables, (1) the sheet forming process (MP and equivalent sheets) and (2) the pressing pressure (1000 and 50 p.s.i.); (3) a fiber property variable (sulfite and kraft fibers); and (4) a sheet property variable (the differences in $\bar{c}_m$ among the 2-, 3-, 4-, and 8-layer sheets). The pertinent point here is that the process variables, particularly (1), did not have a significant effect on any of the four sheet properties studied. Therefore, we believe it is valid to apply the theory of MP sheet structure to equivalent sheets made of softwood fibers. (Some other interesting results of the analyses of variance are discussed later.)

Table III. Properties of 2-D Layers of MP Sheets

Pulp	No. of layers in sheet	Sheets pressed at 1000 p.s.i. — Basis weight per layer, g./sq. cm.	N/L	p(0)	Sheets pressed at 50 p.s.i. — Basis weight per layer, g./sq. cm.	N/L	p(0)
Sulfite	2	2.89×10^{-4}	132.5	0.44	3.00×10^{-4}	137.3	0.43
	3	2.95	135.0	0.43	2.90	133.0	0.44
	4	3.56	164.0	0.37	3.30	151.5	0.39
	8	3.17	145.2	0.40	3.01	138.0	0.43
	12	2.65	121.9	0.47	2.93	134.5	0.43
Kraft	2	3.10	116.3	0.49	2.99	111.7	0.50
	3	3.18	119.5	0.48	2.81	105.6	0.52
	4	2.92	110.0	0.51	2.80	105.2	0.52
	8	3.07	115.5	0.49	2.82	106.0	0.52

Table IV. Mean Number of Crossings per Fiber and Mean Number of Crossings per Millimeter of Fiber Length of Various Layers of MP Sheets

Pulp	Pressing pressure, p.s.i.	No. of layers in sheet	Sheets with measured σ_K's (Table II) (unbeaten pulps), $\bar{c}_K/\bar{\lambda}$ of layer number						Sheets with σ_K's = 1 (Hypothetical well-beaten pulps), $\bar{c}_K/\bar{\lambda}_{(max)}$ for layer number						
			$\bar{c}_m$	1	2	3	4	5	6[a]	$\bar{c}_{m\ (max.)}$	1	2	3	4	5	6[a]
Sulfite	1000	2	31.0	14.1						33.4	15.3					
		3	38.0	16.0	19.8					44.6	18.0	25.0				
		4	47.7	18.5	24.8					54.5	20.9	27.8				
		8	49.1	17.0	22.9	24.5	24.8			56.4	19.2	25.9	28.5	28.9		
		12	47.7	15.8	20.4	23.2	23.6	23.7	23.7	56.5	18.2	24.3	27.3	27.9	28.1	28.1
	50	2	28.6	13.0						34.5	15.7					
		3	33.4	14.0	17.6					45.8	18.4	25.6				
		4	38.0	14.8	19.9					51.3	19.7	26.2				
		8	41.5	14.7	19.4	20.6	20.8			56.5	19.3	25.5	28.7	29.3		
		12	42.5	14.3	18.9	20.1	20.2	20.3	20.4	57.9	18.8	25.3	28.0	28.5	28.6	28.6
Kraft	1000	2	22.2	10.1						29.3	13.3					
		3	26.3	10.3	14.0					37.8	16.2	19.3				
		4	27.9	11.0	14.4					41.1	16.4	21.0				
		8	32.8	11.4	15.1	16.2	16.3			55.1	16.9	22.5	25.2	25.9		
	50	2	18.3	8.3						28.6	13.0					
		3	20.7	8.8	10.7					35.6	15.3	18.0				
		4	22.6	9.0	11.6					40.5	16.1	20.7				
		8	26.0	9.3	12.1	12.9	13.0			49.5	16.7	22.2	25.1	26.0		

[a] Only half the layers shown for reasons of symmetry.

Table V. Mean Free Fiber Lengths of Various Layers of MP Sheets

Pulp	Pressing pressure, p.s.i.	No. of layers in sheet	Sheets with measured σ_K's (Table II) (unbeaten pulps), $\bar{g}_K$ of layer number, cm. $\times 10^3$						Sheets with σ_K's = 1 (Hypothetical well-beaten pulps) $\bar{g}_{K\ (min.)}$ of layer number, cm. $\times 10^3$						
			$\bar{g}_m$	1	2	3	4	5	6	$\bar{g}_{m\ (min.)}$	1	2	3	4	5	6
Sulfite	1000	2	6.63	6.63						6.15	6.10					
		3	5.40	5.83	4.72					4.61	5.19	3.74				
		4	4.30	5.05	3.76					3.77	4.46	3.36				
		8	4.18	5.50	4.08	3.81	3.77			3.65	4.86	3.61	3.28	3.23		
		12	4.30	5.91	4.58	4.03	3.96	3.94	3.94	3.64	5.14	3.84	3.42	3.34	3.32	3.32
Sulfite	50	2	7.19	7.19						5.96	5.95					
		3	6.15	6.68	5.31					4.50	5.07	3.65				
		4	5.40	6.32	4.70					4.01	4.75	3.56				
		8	4.95	6.36	4.82	4.55	4.50			3.64	4.85	3.66	3.25	3.19		
		12	4.83	6.53	4.94	4.65	4.62	4.60	4.58	3.56	4.97	3.69	3.34	3.28	3.26	3.26
Kraft	1000	2	8.38	8.75						6.35	6.65					
		3	7.07	8.59	6.31					4.92	5.46	4.60				
		4	6.66	8.04	6.15					4.53	5.40	4.21				
		8	5.67	7.75	5.86	5.45	5.43			3.38	5.24	3.94	3.51	3.42		
Kraft	50	2	10.15	10.65						6.50	6.81					
		3	8.97	10.05	8.37					5.22	5.79	4.92				
		4	8.23	9.84	7.62					4.60	5.50	4.28				
		8	7.15	9.52	7.31	6.85	6.80			3.75	5.30	3.99	3.53	3.40		

The data in Tables IV and V were calculated using σ_1 instead of $\sigma_1/2$ in equations (9) and (12).

While σ_1 and σ_2 are relatively easy to measure, σ_3 is not, and the values obtained for it are, at best, approximations. However, N_{cm}, $\bar{c}_m$, and $\bar{g}_m$ are primarily functions of σ_1 and σ_2 and are relatively insensitive to large errors in $\sigma_{\geq 3}$. For example, a 25% difference in σ_3 for the 1000-p.s.i. sulfite pulp will cause only a 2% change in $\bar{c}_m$, a value well within the experimental errors of the techniques involved.

The σ values are consistent with two well-known concepts of fiber flexibility:

(a) Unbeaten, unbleached softwood sulfite fibers are more flexible than the corresponding kraft fibers.

Table VI. Specific Volume of MP and Equivalent Sheets

Pulp	No. of layers	Specific volume of sheets pressed at 1000 p.s.i., cc./g.		Specific volume of sheets pressed at 50 p.s.i., cc./g.	
		MP	Equivalent	MP	Equivalent
Sulfite	2	3.1	2.7	3.0	3.3
	3	2.6	2.5	2.8	2.4
	4	2.1	2.4	2.1	2.2
	8	1.6	1.7	1.8	1.9
Kraft	2	3.7	4.1	3.8	3.9
	3	2.7	3.1	3.0	2.9
	4	2.4	4.0	2.7	3.1
	8	1.8	2.2	2.3	2.5

(b) Raising the wet pressing pressure increases the amount of interfiber bonding.

In the present study, it was found that raising the pressure increases the number of crossings formed. Sufficient data are not available yet to permit us to draw conclusions on the effect of pressing on the quality of the bonding of the crossings; this subject will be covered in a later article in this series on paper structure.

It was pointed out earlier that $\bar{c}_K$ and $\bar{g}_K$ vary from layer to layer in an MP sheet. Although these differences are negligible from the third layer inward, they are appreciable between the edge and central layers, in the ratio of 1:1.3 and 1:1.5. Thus, the porosity of the edge layers is greater than in the rest of the sheet. This difference may be of considerable importance in applications involving surface phenomena and the penetration of solids and fluids into the sheet; i.e., coating, printing, saturation, etc.

Table IV shows that $\bar{c}_m$ for spruce fibers varies from about 18 for relatively rigid fibers pressed at low pressures to about 57 in a sheet where all crossings are formed. Thus, the value of $\bar{c}_m$ must be appreciably affected by the process variables. In the present investigation, the obtainable increases in $\bar{c}_m$ were much

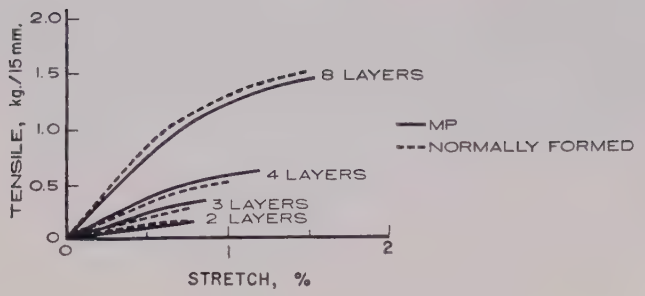


Fig. 3a. Stress–strain curves of MP and equivalent normally formed sheets
Kraft pulp—1000 p.s.i. pressure

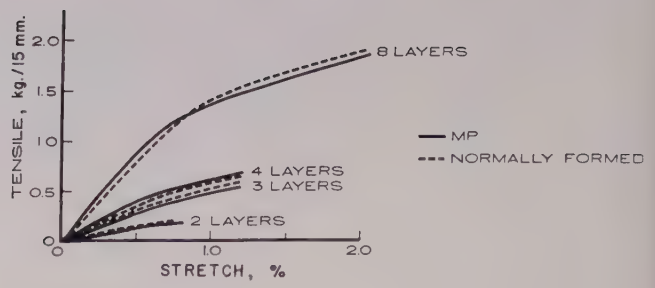


Fig. 3b. Stress–strain curves of MP and equivalent normally formed sheets
Kraft pulp—50 p.s.i. pressure

greater for the kraft than for the sulfite pulp, 81% and 51% (over the values at the two original pressing levels) versus 37% and 16%. These changes are of the same order-of-magnitude as the increases in the breaking load obtained during a beater run (see Table VIII). Thus, we suspected that changes in the breaking load, and possibly other mechanical properties of paper, may be closely related to changes in $\bar{c}_m$. Such relationships would not only help to verify the MP structure theory, but should make it possible to apply it in the immediate future.

$$\frac{S}{W \times \bar{c}_m} = U\bar{c}_m + V, \qquad (23)$$

where $U = 0.017$ and $V = 0.942$ for the sulfite pulp, and $U = 0.039$ and $V = 1.38$ for the kraft pulp, had correlation coefficients of 0.86,–0.89 (sulfite), and −0.92 (kraft), respectively. The ratio $T/(R)(W)(\bar{c}_m)$ (where T is the breaking load and R is the width of the sample) had almost the same constant value for

Table VII. Mechanical Properties of MP and Equivalent Sheets

Pulp	Pressure, p.s.i.	No. of layers	Elastic modulus/unit mass,[a] cm. MP	Elastic modulus/unit mass,[a] cm. Equivalent	Breaking load/unit width/unit mass,[b] cm. MP	Breaking load/unit width/unit mass,[b] cm. Equivalent	Fractional stretch per unit mass, cm.²/g. MP	Fractional stretch per unit mass, cm.²/g. Equivalent
Sulfite	1000	2	5.5×10^7	5.2×10^7	3.2×10^5	3.3×10^5	15.1	13.6
		3	5.5	6.0	4.1	4.9	12.6	13.0
		4	5.9	5.9	5.3	5.1	10.5	10.8
		8	5.8	5.8	6.1	6.4	7.8	7.4
		12	6.5	..	7.0	..	5.9	..
	50	2	5.4	..	3.1	..	13.8	..
		3	5.8	5.9	3.7	4.3	11.3	9.8
		4	6.4	5.9	5.3	4.6	9.8	10.1
		8	6.1	6.0	5.6	6.5	6.6	7.8
		12	6.2	..	6.4	..	5.4	..
Kraft	1000	2	3.6	3.8	2.0	2.1	12.7	14.0
		3	4.6	5.0	3.5	3.4	11.1	11.7
		4	4.9	3.8	3.6	2.3	7.4	7.8
		8	5.2	5.6	4.9	5.9	7.6	9.3
	50	2	3.3	3.8	1.6	1.7	12.8	20.6
		3	4.1	4.1	2.5	2.7	12.3	13.5
		4	4.8	3.5	3.1	2.1	8.1	9.3
		8	5.0	4.7	4.0	4.2	6.8	6.6

[a] Elastic modulus = force/unit width/weight/unit air. [b] g. cm.$^{-1}$/g. cm.$^{-2}$.

Two of the mechanical properties, the elastic modulus, Y, and fractional stretch, S, of *both* pulps at *both* pressing pressures are plotted as a function of $\bar{c}_m$ in Figs. 4 and 5. The linear relationships for *both* pulps are:

$$\left(\frac{Y}{W}\right)^{1/3} \times 10^3 = 0.043\ \bar{c}_m + 6.62 \qquad (22)$$

both pulps, 1.3×10^4 cm., for all of the data, and a value of 1.4×10^4 cm. for the 4-, 8-, and 12-layer sheets alone. (The 2- and 3-layer sheets may have been too light to give a true statistical mean.) These data suggest that $\bar{c}_m$ is one of the most fundamental variables affecting the mechanical properties of paper. Although it is too early to draw any conclusions from the data, it appears that the elastic modulus and tensile

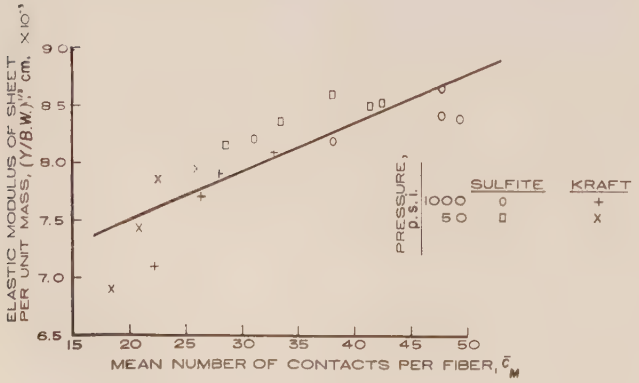


Fig. 4. Elastic modulus of sheet per unit mass as a function of mean number of crossings per fiber

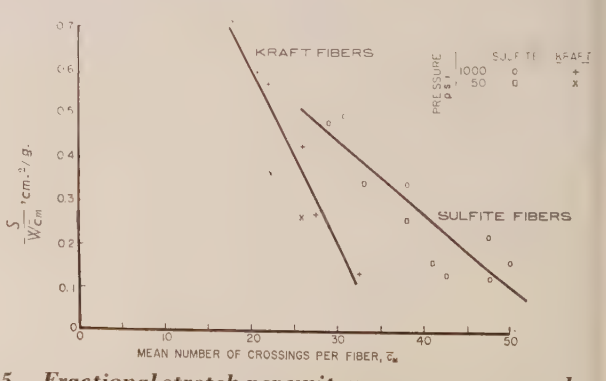


Fig. 5. Fractional stretch per unit mass per mean number of crossings per fiber [$S/(W \times \bar{c}_m)$] as a function of mean number of crossings per fiber

Table VIII. Effect of Beating on Maximum Breaking Load of Unbleached Spruce Sulfite and Kraft Pulps[a]

	Breaking load, meters		
	Unbeaten pulp	*Beaten pulp*	*% Increase*
Sulfite	7000	10,000	43
Kraft	8000	15,000	87

[a] Data supplied by R. Hamilton, Pulping Research Group, St. Regis Paper Co.

2. From the relationships between sheet properties and the *maximum possible* sheet properties, pulp evaluation by calculations rather than by arbitrary beater run curves should be possible. This step should eventually lead to analyses and control of the processes by computers.

3. From the paper-fiber relationships, it should be possible to design papers for specific purposes from a selection of the most suitable fibers and the optimum process variables.

We feel that the above goals, though extremely ambitious, are now definitely within grasp.

Table IX. Mechanical Properties of MP Sheets per Mean Number of Crossings per Fiber

Pulp	*Pressure, p.s.i.*	*No. of layers*	*Elastic modulus/unit mass/ mean number of crossings per fiber, cm./$\bar{c}_m$*	*Breaking load/unit width/unit mass/mean number of crossings per fiber, cm. × $10^4/\bar{c}_m$*	*Fractional stretch/unit mass/ mean number of crossings per fiber, $cm.^2/g./\bar{c}_m$*
Sulfite	1000	2	1.8×10^6	1.0	0.49
		3	1.5	1.1	0.33
		4	1.2	1.4	0.22
		8	1.2	1.4 } 1.4	0.16
		12	1.4	1.5	0.12
	50	2	1.9	1.1	0.48
		3	1.7	1.1	0.34
		4	1.7	1.4	0.26
		8	1.5	1.4 } 1.4	0.16
		12	1.5	1.5	0.13
Kraft	1000	2	1.6	0.9	0.57
		3	1.8	1.4	0.42
		4	1.8	1.3	0.27
		8	1.6	1.5 } 1.4	0.23
	50	2	1.8	0.9	0.71
		3	2.0	1.2	0.59
		4	2.2	1.4	0.36
		8	1.9	1.5 } 1.4	0.26

Table X. Relative Effects of Two Pulping Processes and Sheet Structure on Four Paper Properties

	Per cent effect[a]		
	Pulping process	*Variations in $\bar{c}_m$*	*Residual*
Specific volume, cc./g.	30	55	15
Elastic modulus, g./cm.	75	13	12
Breaking load, g.	42	48	10
Fractional stretch	0	78	22

[a] All significant at 0.001 level.

strength are more dependent on interfiber properties, i.e., the number and strength of the crossings, than on the fiber properties themselves, while the stretch is a function of both.

The above findings were supported by the results of the analyses of variance (see Table X). It was found that only the fiber and sheet property variables [(3) and (4)] had a significant effect on the four paper properties. Although pressing had the effect of varying $\bar{c}_m$, pressing in itself had no effect on the paper properties. This result suggests that the evaluation of $\bar{c}_m$ is a direct method for studying the effect of pressing and other process variables on paper properties.

The excellent correlations between the various paper properties and $\bar{c}_m$ indirectly verify the theory of MP sheet structure. More important, they demonstrate that paper properties can be related to each other, to the fiber properties, and to the process variables. Thus, the MP sheet structure theory, or a similar but more general theory not based on layers, could become the basis for a "science of paper." The applications of such a "science" in the paper industry are so numerous that no complete list can be drawn up at this time. However, we would like to mention a few possibilities:

1. Quantitative theories of paper behavior in terms of their mechanisms will permit the paper technologist to analyze papermaking problems in terms of the phenomena taking place rather than in terms of the changes in arbitrary and often empirical tests.

LITERATURE CITED

1. Kallmes, O. and Corte, H., *Tappi* 43, No. 9: 737–752 (Sept., 1960).
2. Kallmes, O., "The Mechanical Properties of Paper, Part I: The Elastic Properties of an Ideal Multiplanar Sheet." To be presented at the Symposium on Formation and Structure of Paper, Oxford, England, 1961.
3. Page, D. H., *Paper Technology* 1, No. 4: 407–411 (Aug., 1960).
4. Page, D. H. and Tydeman, P. A., *Paper Technology* 1, No. 5: 519–530 (Oct., 1960).

Received April 7, 1961.

We would like to express our sincere appreciation to Dr. M. Stone of Princeton University for his assistance with the mathematical parts of the theory; to Miss M. Cauley and Mr. M. Nieboer for their assistance in the experimental work; to St. Regis Paper Co., in particular Dr. K. A. Arnold; and to The Wiggins Teape Co., Ltd., in particular Dr. H. F. Rance, for permission to publish the results of the investigation.

APPENDIX I

Total Number of Crossings in an MP Sheet

The total number of crossings in an N_L layer MP sheet is the sum of the crossings within the layers and between the layers. The number of crossings within the layer is:

$$N_L N_c' B \sigma_1 \qquad \text{(A1)}$$

The total number of crossings between the layers is found as follows:

Consider the top ($K = 1$) layer of a sheet. It makes

$$2N_c' B^2 \sigma_2$$

crossings with the layer directly beneath it; i.e., $K = 2$. The number of crossings between the top and third layers is

$$2N_c' B^2 \sigma_3 p(0) \qquad \text{(A2)}$$

where $p(0)$ is the fractional open area of the second

layer through which crossings can be made. The number of crossings between the top and Kth layer, setting, σ_K proportional to $p(0)^{K-2}$ (see the section Total Number of Crossings), is

$$2N_c'B^2Cp(0)^{2(K-2)}$$

The total number of crossings between the top layer and all of the other layers of the sheet is:

$$2N_c'B^2\{\sigma_2 + C[p(0)^2 + p(0)^4 + \ldots + p(0)^{2(N_L-2)}]\} = 2N_c'B^2\left\{\sigma_2 + \frac{Cp(0)^2[1-p(0)^{2(N_L-2)}]}{[1-p(0)^2]}\right\} \quad (A3)$$

The number of crossings between the Kth layer and all of the other layers below it is:

$$2N_c'B^2\left\{\sigma_2 + \frac{Cp(0)^2\,[1-p(0)^{2(N_L-K-1)}]}{[1-p(0)^2]}\right\}. \quad (A4)$$

The total number of crossings between all pairs of layers of an MP sheet is found by summing up equation (A4) with values of $K = 1, 2, \ldots, (N_L - 1)$ or

$$\frac{2N_c'B^2}{[1-p(0)^2]}\left\{(N_L-1)[\sigma_2\{1-p(0)^2\} + Cp(0)^2] - Cp(0)^2\,[p(0)^{2(N_L-2)} + p(0)^{2(N_L-3)} + \ldots + p(0)^{2(0)}]\right\}$$
$$= 2N_c'B^2\left\{(N_L-1)\left[\sigma_2 + \frac{Cp(0)^2}{1-p(0)^2}\right] - \frac{Cp(0)^2[1-p(0)^{2(N_L-1)}]}{[1-p(0)^2]^2}\right\} \quad (A5)$$

The total number of crossings in an MP sheet, N_{cm}, is the sum of expressions (A1) and (A5), or equation (7).

$$N_{cm} = N_c'N_LB\left[\sigma_1 + 2B\left\{\left(1-\frac{1}{N_L}\right)\left(\sigma_2 + \frac{Cp(0)^2}{1-p(0)^2}\right) - \frac{Cp(0)^2\,[1-p(0)^{2(N_L-1)}]}{N_L[1-p(0)^2]^2}\right\}\right] \quad (7)$$

APPENDIX II

The Average Number of Crossings per Fiber of Fibers in the Kth Layer

It was shown in Appendix I that in an N_L layer sheet, the number of crossings between the fibers of the Kth layer and all of the layers below it, if $K \leqslant N_L - 1$, is given by equation (A4).

Using the same considerations, it can be shown that the number of crossings between the fibers of the Kth layer and the layers above it, if $K \geqslant 2$, is:

$$2N_c'B^2\left\{\sigma_2 + \frac{Cp(0)^2\,[1-p(0)^{2(K-2)}]}{[1-p(0)^2]}\right\} \quad (A6)$$

When $2 \leqslant K \leqslant N_L - 1$, the number of crossings between the fibers of the Kth layer and the other layers of the sheet is the sum of equations (A4) and (A6), and $N_c'B\sigma_1$. Thus, the number of crossings per fiber of the fibers of the Kth layer is given by equation (9).

$$\bar{c}_K = \bar{c}'B\left\{\sigma_1 + B\left[2\sigma_2 + \frac{Cp(0)^2}{1-p(0)^2}\,[2 - p(0)^{2(N_L-K-1)} - p(0)^{2(K-2)})]\right]\right\} \quad (9)$$

APPENDIX III

Original Data

Pulp	*Pressure, p.s.i.*	*No. of layers*	*Basis weight, g./cm.²* MP	*Basis weight, g./cm.²* Equivalent	*Thickness, cm.* MP	*Thickness, cm.* Equivalent	*Tensile strength,[a] g./15 mm. width* MP	*Tensile strength,[a] g./15 mm. width* Equivalent	*Stretch,[a] %* MP	*Stretch,[a] %* Equivalent	*Elastic modulus,[a] g./cm.* MP	*Elastic modulus,[a] g./cm.* Equivalent
Sulfite	1000	2	5.7×10^{-4}	6.6×10^{-4}	17.8×10^{-4}	17.8×10^{-4}	272	332	0.86	0.90	3.1×10^4	3.4×10^4
		3	8.9	9.3	22.9	22.9	553	696	1.12	1.21	4.9	5.6
		4	14.2	11.7	30.5	28.0	1138	895	1.50	1.36	8.6	6.8
		8	25.3	23.7	40.7	40.7	2322	2297	1.96	2.00	14.0	13.7
		12	31.8	...	...	...	3345	...	1.89	...	20.8	...
	50	2	6.0	5.4	20.3	17.8	282	277	0.83	0.71	3.2	...
		3	8.7	10.6	24.2	25.4	509	683	0.98	1.04	5.0	6.2
		4	13.2	12.5	28.0	28.0	1058	864	1.28	1.26	8.4	6.7
		8	24.1	22.6	43.2	43.2	2007	2210	1.58	1.76	14.7	13.6
		12	35.1	...	...	...	3440	...	1.95	...	21.9	...
Kraft	1000	2	6.2	5.6	22.9	22.9	187	175	0.85	0.78	2.2	2.1
		3	9.5	7.4	25.4	22.9	495	374	1.23	1.05	4.3	3.7
		4	11.7	10.2	28.0	40.7	637	347	1.19	0.79	5.7	3.9
		8	24.5	20.0	43.2	43.2	1803	1752	1.96	1.87	12.9	11.7
	50	2	6.0	3.9	22.9	15.2	142	101	0.77	0.81	2.0	1.5
		3	8.4	7.1	25.4	20.3	312	290	0.91	0.96	3.5	2.9
		4	11.2	8.9	30.5	28.0	529	285	1.04	0.83	5.4	3.1
		8	22.5	24.3	50.8	61.0	1350	1528	1.53	1.60	11.2	11.4

[a] All testing was done at a constant rate of elongation, 3% per min., at 50 ± 2% R.H.

Erratum

Investigation of the Mannans and Xylans in Softwood. II

ALFRED J. MORAK AND KYLE WARD, JR., *Tappi* 44, No. 1: 12–22 (Jan., 1961)

The column headings to Table IV, p. 15, should be as shown below:

Table IV. Composition of the Isolated Hemicelluloses and Average Molecular Weight of the Monomer

No correction made for destruction of sugars during hydrolysis

		KOH extns.			
		1st		*2nd*	*3rd*
Sample	*Polysaccharide, %*	*Insol. in 70% ethanol*	*Sol. in 70% ethanol in dialyzate*	*Sol. in 70% ethanol in diffusate*	

ASSOCIATION NEWS AND EVENTS

National Conferences

1961

Lignin Symposium, Aug. 14–16, 1961, Edgewater Beach Hotel, Chicago, Ill.

Twelfth Testing Conference, Aug. 15–18, 1961, Queen Elizabeth Hotel, Montreal, Que.

Eleventh Corrugated Containers Conference, Sept. 6–8, 1961, St. Francis Hotel, San Francisco, Calif.

Fourth International Mechanical Pulping Conference, Sept. 19–21, 1961, Edgewater Beach Hotel, Chicago, Ill.

Sixth Deinking Conference, Oct. 4–6, 1961, Hotel Harris, Kalamazoo, Mich.

Sixteenth Plastics-Paper Conference, Oct. 9–11, 1961, French Lick Sheraton Hotel, French Lick, Ind.

Sixteenth Engineering Conference, Oct. 15–19, 1961, Shoreham, Hotel, Washington, D. C.

Fifteenth Alkaline Pulping Conference, Nov. 1–3, 1961, Rice Hotel, Houston, Tex.

1962

Forty-seventh Annual Meeting, Feb. 18–22, 1962, Commodore Hotel, New York, N. Y.

Thirteenth Coating Conference, May 14–16, 1962, Netherland-Hilton Hotel, Cincinnati, Ohio.

Thirteenth Testing Conference, Sept. 18–20, 1962, Benjamin Franklin Hotel, Philadelphia, Pa.

Seventeenth Plastics-Paper Conference, Oct. 8–11, 1962, Statler-Hilton Hotel, Boston, Mass.

Seventeenth Engineering Conference, Oct. 14–19, 1962, Queen Elizabeth Hotel, Montreal, Que.

Twelfth Corrugated Containers Conference, Oct. 23–26, 1962, Statler-Hilton Hotel, Boston, Mass.

Sixteenth Alkaline Pulping Conference, Oct. 31, Nov. 1–2, 1962, DeSoto Hotel, Savannah, Ga.

1963

Fourteenth Coating Conference, May 19–22, 1963, Concord Hotel, Kiamesha Lake, N. Y.

Thirteenth Corrugated Containers Conference, Oct. 22–25, 1963, Statler-Hilton Hotel, Detroit, Mich.

Eighteenth Engineering Conference, Oct. 28–31, 1963, Netherland-Hilton Hotel, Cincinnati, Ohio.

Other Associations

Technical Section of the British Paper and Board Makers' Association, Sept. 25–29, 1961, Symposium: The Formation and Structure of Paper, Oxford, England.

Papirindustriens Tekniske Forening, Dec. 5–6, 1961, Technical Convention, Oslo, Norway.

Agriculture Fibers Committee

T. F. Clark, Northern Utilization Research and Development Division, Agricultural Research Service, U.S.D.A., Peoria, Ill., has been appointed chairman of the Agriculture Fibers Committee by H. M. Annis, president of TAPPI.

Mr. Clark is head, Fibrous Products Investigations and is concerned with the composition and properties of celluloses, hemicelluloses, and related constituents from fibrous plants. His group is also concerned with the development from raw materials; products such as dissolving pulps, paper, structural board, cordage; feedstuffs and cellulose derivatives; and improved processes for their preparation.

Mr. Clark received a B.S. in Chemical Engineering degree from the University of Minnesota, and a Master of Science (Chemistry) from Bradley University. He has also done graduate study at Iowa State University.

Mr. Clark has been active in the Agriculture Fibers Committee since 1955, having been secretary and vice-chairman. He has presented technical papers at TAPPI Annual Meetings in 1957, 1959, 1960, and 1961.

Coating Committee

C. G. Landes, consultant, Charlotte, N. C., has recently been appointed chairman of the Coating Committee, of the Technical Association of the Pulp and Paper Industry.

Mr. Landes is professor of pulp and paper technology at North Carolina State College, Raleigh, N. C., and is a private paper consultant to several firms.

He is a graduate of Ohio State University in Columbus, Ohio, with a B.Ch.E. degree, and has also studied at the Polytechnic Institute of Brooklyn in New York.

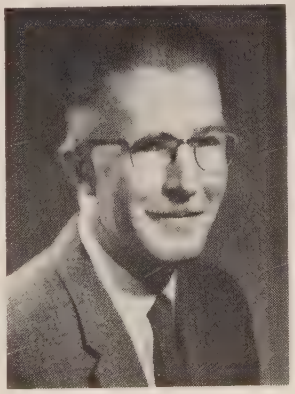
He is a member of the American Chemical Society, Technical Association of the Graphic Arts, American Association of Textile Chemists and Colorists and TAPPI. He has been very active in various committees of TAPPI, since joining the association in 1926. He presented a paper at the 1954 Coating Conference.

Mr. Landes heads up a council of four other executives in the paper field upon whom rest the direction of all activities of the TAPPI Coating Committee.

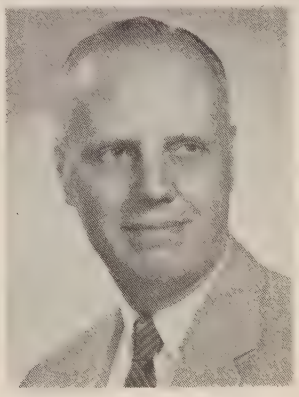
Pulp Purification Committee

R. J. Auchter, Kimberly-Clark Corp., Neenah, Wis., has been appointed chairman of the Pulp Purification Committee by Harold M. Annis, president of TAPPI.

Mr. Auchter has been quite active in Pulp Purification

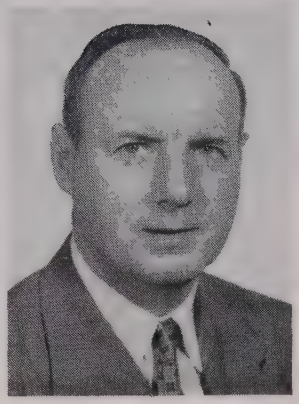


T. F. Clark, Agricultural Research Service, USDA; chairman, Agriculture Fibers Committee



C. G. Landes, North Carolina State College; chairman, Coating Committee

R. J. Auchter, Kimberly-Clark Corp.; chairman, Pulp Purification Committee



C. S. Maxwell, consultant; chairman, Wet Strength & Interfiber Bonding Committee

Committee activities, having acted as technical program chairman for the most successful International Pulp Bleaching Conference held last June in Chicago. In addition, Mr. Auchter acted as vice-chairman of the committee of the past year.

Mr. Auchter is manager, Pulp and Wood Preparation Dept., Research and Development, Kimberly-Clark Corp. He was graduated from Marquette University and holds a B.S. in Chemical Engineering degree.

Wet Strength and Interfiber Bonding Committee

Charles S. Maxwell, 23 Stuart Drive, Old Greenwich, Conn., chemical consultant in the paper industry, was appointed chairman of the Wet Strength & Interfiber Bonding Committee of the Technical Association of the Pulp & Paper Industry in April.

Mr. Maxwell is a graduate of Colgate University with a B.A. degree and graduated from Syracuse University with a M.A. degree in 1936. He has a broad background in chemistry both from schooling and practical experience. He has numerous patents registered in the United States and in foreign countries, with other United States patents pending all pertaining to the paper industry. Over a dozen of Mr. Maxwell's papers have been published in trade journals and he has presented many papers at technical conferences all over the country.

Mr. Maxwell is a member of the American Chemical Society as well as a member of the Technical Association of the Pulp and Paper Industry (TAPPI).

Lignin Symposium

The following technical program for the TAPPI Lignin Symposium has been announced by W. M. Hearon, Crown Zellerbach Corp., San Francisco, Calif. The symposium, sponsored by the Wood Chemistry Committee, will feature outstanding workers in the field of lignin chemistry who will present 15 papers on the theme "Lignin—Greater Utilization Through Better Understanding."

In addition, there will be a panel discussion moderated by H. F. Lewis, the Institute of Paper Chemistry, Appleton, Wis., on the subject of "Where Do We Go from Here."

A high point of the symposium will be an address by Dr. Holger Erdtman, the Royal Institute of Technology, Stockholm, Sweden, who will speak on the subject "A Chemist Looks at the Forest."

J. R. Salvesen, Marathon Div. of American Can Co., Rothschild, Wis., is general chairman for the Symposium.

Those planning to attend the symposium should write for hotel reservations to:

TAPPI Lignin Symposium
Edgewater Beach Hotel
Chicago 40, Ill.

stating times and dates of both arrival and departure. The Edgewater Beach Hotel will confirm the reservations directly to the individuals.

TECHNICAL PROGRAM

SUNDAY, AUG. 13, 1961

3:00 p.m. Wood Chemistry Committee (Lincoln Room)

3:00 p.m.–8:00 p.m. Registration (Passagio)

MONDAY, AUG. 14, 1961

8:00 a.m.–5:00 p.m. Registration (Passagio)

9:00 a.m. Symposium Introduction (East Lounge)

J. R. Salvesen, Marathon Div. of American Can Co., Rothschild, Wis.

9:15 a.m. Session I

W. M. Hearon, Crown Zellerbach Corp., San Francisco, Calif., *Moderator*

1. "The Separation of the Components in Spent Sulfite by Waldemar Jensen, Kaj-Erik Fremer, and Kaj Forss, Finnish Pulp and Paper Research Institute, Helsinki, Finland.

9:45 a.m.

2. "Determination of Reducing Bodies in Lignosulfonates," by J. Giguère, Lignosol Chemicals, Ltd., Quebec, Que.

10:45 a.m.

3. "Factors Affecting Evaluation of Dispersing Agents," by M. A. Baum, E. E. Harris, and R. F. Benning, Marathon Div. of American Can Co., Rothschild, Wis.

11:25 a.m.

4. "The Effect of Molecular Size on Surface-Active Properties of Lignosulfonates," by J. Benko, Sulphite Pulp Manufacturers' Research League, Appleton, Wis.

1:30 p.m. Session II (East Lounge)

A. S. Gregory, Weyerhaeuser Co., Tacoma, Wash., *Moderator*

5. "New Utilization Prospects of Sulphite Liquor in the Federal Republic of Germany," by Wolfgang H. Gloz, Chemische Werke Zell-Wildshausen G.m.b.H., Düsseldorf, Germany.

2:30 p.m.

6. "Studies on the Chemistry of Aspenwood. XIII. The Ether-Soluble Portion of Spent Sulfite Liquor from Authentic Quaking Aspenwood," by I. A. Pearl and D. L. Beyer, the Institute of Paper Chemistry, Appleton, Wis.

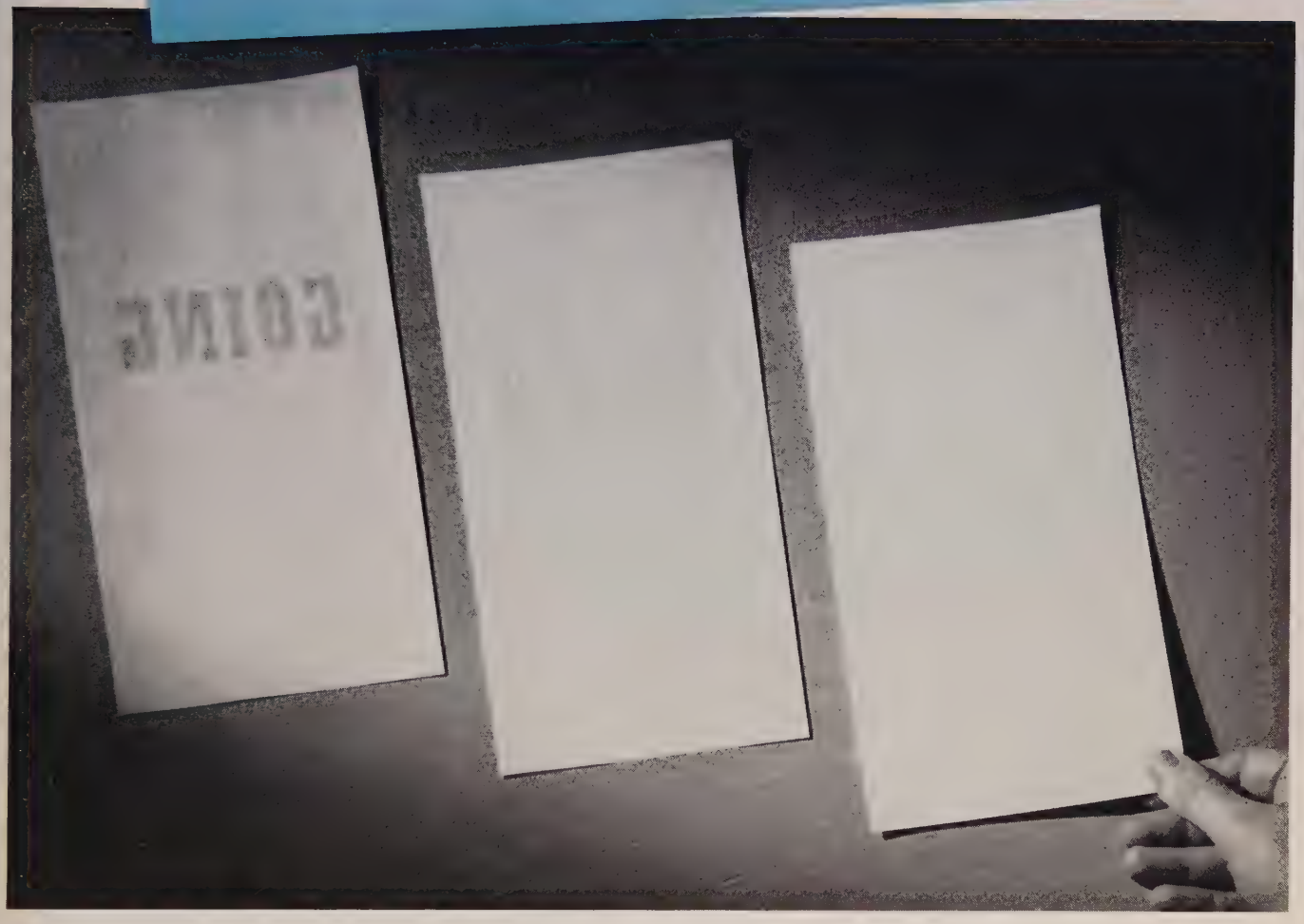
3:35 p.m.

7. "The Oxidation of Lignin Model Compounds and Wood Meal with Chlorine Dioxide and Sodium Chlorite," by C. Dence, State University College of Forestry Syracuse University, Syracuse, N. Y.

1:35 p.m.

8. "IR-Investigations of Lignin—A Discussion of Some Recent Results," by S. Kolboe, Central Institute of Industrial Research, Oslo, Norway, and O. Ellefsen, The Norwegian Pulp and Paper Research Institute, Oslo, Norway.

SHOW-THROUGH



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TUESDAY, AUG. 15, 1961

8:00 a.m.–12:00 M Registration (Passagio)

9:00 a.m. Session III (East Lounge)

G. H. Tomlinson II, Howard Smith Paper Mills, Ltd., Cornwall, Ont., *Moderator*

9. "The Precipitation of Lignin from Eucalyptus Kraft Black Liquors," by J. W. T. Merewether, Ivanhoe, Victoria, Australia.

9:40 a.m.

10. "Development of Useful Products from Kraft Lignin," by P. R. Wiley, West Virginia Pulp and Paper Co., Charleston, S. C.

11:20 a.m.

11. "Lignin and Plastics," by K. Kratzl, University of Vienna and Austrian Wood Research Institute, Vienna, Austria.

1:30 p.m. Session IV (East Lounge)

F. J. Ball, West Virginia Pulp & Paper Co., Charleston, S. C., *Moderator*

12. "The Degradation of Lignin by Alkali," by Josef Gierer, Swedish Forest Products Research Laboratory, Stockholm, Sweden.

2:10 p.m.

13. "The Demethylation and Degradation of Lignin or Spent Liquors by Heating with Alkaline Reagents," by Terje Enkvist, Johannes Turunen, and Theodore Ashorn, University of Helsinki, Helsinki, Finland.

3:40 p.m.

14. "Sulfur Chemicals from Lignin," by W. M. Hearon, W. S. MacGregor, and D. W. Goheen, Crown Zellerbach Corp., Camas, Wash.

6:00 p.m. Reception (East Lounge)
7:30 p.m. Banquet (South Terrace)

Speaker: Holger Erdtman, The Royal Institute of Technology, Stockholm, Sweden

Title: "A Chemist Looks at the Forest"

WEDNESDAY, AUGUST 16, 1961

9:00 a.m. Session V (East Lounge)

D. L. Brink, University of California Forest Products Laboratory, Richmond, Calif., *Moderator*

15. "Lignin Liquefaction by High Pressure Hydrogenation," by M. Oshima and K. Kashima, The Noguchi Institute, Tokyo, Japan.

10:30 a.m.

16. Panel Discussion: "Where Do We Go From Here?" Panel Moderator: H. F. Lewis, The Institute of Paper Chemistry, Appleton, Wis.

12:00 M Adjournment

2:00 p.m. Wood Chemistry Committee (Sheridan Room)

Bibliography of Paper Making—1960

Labels requesting this book were sent to all members. Any member desiring this publication who has not already notified the Association should write immediately or send in the filled-out label.

Twelfth Testing Conference

The twelfth Testing Conference of TAPPI being held at the Queen Elizabeth Hotel, Montreal, Que., Aug. 15–17, 1961, is jointly sponsored by the Technical Section, CPPA. Outstanding features of the three-day meeting are a Symposium on International Standardization and a technical session completely devoted to newsprint testing. Formal papers are being scheduled for presentation in the morning, leaving the afternoons free for committee meetings or visits to the mills in the Montreal vicinity.

Dr. Lennart Stockman, director of The Central Laboratories of the Swedish Cellulose Industry, will discuss the SCAN methods and their adoption by the Scandinavian countries. Also featured in the Symposium on International Standardization will be Miss Karin Wilson, chairman of ICCA, who will speak on the program and achievements of ICCA. ICCA is holding its Annual Meeting in Montreal on Monday, August 14, immediately prior to the Testing Conference. Dr. Waldemar Jensen, managing director of the Finnish Pulp and Paper Research Institute, will tell of the organizations active in the field of international standardization of pulp and paper analysis. Dr. Robert B. Hobbs, Chief, Paper Section of the National Bureau of Standards, who is also Chairman of the U. S. Advisory Committee for International Standardization, will chair the Symposium.

Newsprint testing has long been important in Canada. The technical session devoted to newsprint testing will be of real interest to the industry.

The tentative technical program, as developed by J. E. Tasman, Pulp and Paper Research Institute of Canada, Montreal, Que., is as follows:

Physical Testing

"Notes on the Dispersant Requirements of TiO_2," by W. R. Willets and J. J. Lane, Titanium Pigment Corp., New York, N. Y.

"Determination of Particle Size Distribution of Pigments," by A. C. Dreshfield, The Glidden Co., Baltimore, Md.

"Measurement of Weight Average Fiber Lengths," by J. d'A. Clark, Oregon State College, Corvallis, Ore.

"The Shear Strength of Individual Fiber-Fiber Bonds," by C. H. Mayhood, Jr., O. J. Kallmes and M. M. Cauley, St. Regis Paper Co., Watertown, N. Y.

"Water Vapor Transfer through Multiple Barriers," by K. W. Ninnemann, Olin Mathieson Chemical Corp., New Haven, Conn.

Newsprint Testing

"Newsprint Quality Control," by V. N. DeFelice, St. Croix Paper Co., Woodland, Me.

"Relationship Between Physical Properties and Pressroom Running Performance," by G. Larocque, News Syndicate Co., New York, N. Y.

"Relationship of Printability to Newsprint Formation," by C. A. Sankey, Ontario Paper Co., Ltd., Thorold, Ont.

Chemical Testing

"Radioactive Tracers in Paper Analysis," by F. J. Domingues, General Measurements, Inc., Gardnerville, N. Y.

"Flame Photometry as an Analytical Technique," by C. S. Joyce, Pulp & Paper Research Institute of Canada, Montreal, Que.

"Trace Heavy Metals Analysis in Box Boards," by E. C. Stivers, Arthur D. Little, Inc., Cambridge, Mass.

"Homogeneity of Ash Values from Small Test Specimens," by L. T. Milliken, National Bureau of Standards, Washington, D. C.

Symposium on International Standardization

"Organizations Active in the Field of Pulp and Paper Analysis," by W. Jensen, The Finnish Pulp & Paper Research Institute, Helsinki, Finland

"International Committee on Cellulose Analysis," by Miss K. Wilson, Swedish Forest Products Research Laboratory, Stockholm, Sweden

"The 'SCAN' Methods," by L. G. Stockman, Central Laboratory of the Swedish Cellulose Industry, Stockholm, Sweden

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An outstanding exhibit of testing instruments has been arranged by W. F. Bachelder of Testing Machines, Inc., Mineola, Long Island, N. Y., exhibits chairman of the Conference. The following companies will exhibit equipment:

Hunter Associates Laboratory, Inc.
Emerson Apparatus Co.
Manufacturers Engineering & Equipment Corp.
Williams Apparatus Co., Inc.
Instron Engineering Corp.
Thwing-Albert Instrument Co.
Testing Machines, Inc.
The Robert Mitchel Co., Ltd. (Montreal)
Measurement Engineering, Ltd. (Ontario)

Visitors traveling to the conference may wish to tour the mills of the E. B. Eddy Co., Hull, Que., or the Howard Smith Paper Mills, Ltd., at Cornwall, Ont., on Monday, August 14, the day immediately preceding the Conference. Those arriving at the mills at the specified times will be given complete tours of the facilities.

10:00 a.m. Howard Smith Paper Mills, Ltd., Cornwall, Ont.
Sulfite and kraft pulp mills, paperboard and fine paper machines
2:00 p.m. Howard Smith Paper Mills, Ltd., Cornwall, Ont.
The E. B. Eddy Co., Hull, Que.
Sulfite and groundwood mills, newsprint, paperboard and fine paper machines

Cornwall and Hull lie just off the main highways from much of the United States to Montreal. Almost all planes from Toronto and the west stop at Ottawa which is right across the river from Hull. Stopover privileges are accorded by the airlines and railroads. Flights leave Toronto at 7:30, 9:25, and 11:15 p.m. with 1 hr. flying time. Flights leave Ottawa for Montreal at 5:00 and 7:20 p.m. with 35 min. flying time. Trains leave Ottawa for Montreal at 4:30 and 5:05 p.m. with about 2 hr. travel time.

Cornwall lies on the mainline between Toronto and Montreal. Trains leave Toronto at 10:15 a.m., 5:15 p.m. and 12:30 a.m. with a 5 hr. travel time. Trains continue on to Montreal at 3:10, 4:55, and 10:03 p.m. with $1^1/_2$ to 2 hr. traveling time.

On Friday, August 18, the day immediately following the conference, these two mills will again be open to visitors from the conference. In addition, visitors may wish to tour one or two mills in the Three Rivers area which lies on the direct route from Montreal to historic Quebec.

10:00 a.m. Howard Smith Paper Mills, Ltd., Cornwall, Ont.
The E. B. Eddy Co., Hull, Que.
2:00 p.m. Howard Smith Paper Mills, Ltd., Cornwall, Ont.

Three Rivers Area:

Canadian International Paper Co., Three Rivers, Que.
Sulfite and groundwood mills, newsprint machines
The St. Lawrence Corp., Three Rivers, Que.
Sulfite and groundwood mills, newsprint machines
The Consolidated Paper Corp., Three Rivers, Que.
Kraft and groundwood mills, newsprint and kraft machines
The Consolidated Paper Corp., Ltd., Grand' Mere, Que.
Sulfite, kraft and groundwood mills, paperboard, newsprint and kraft paper machines

Trains leave Montreal at 7:10, 9:10 a.m., 12:20, 5:15, and 6:25 p.m. and travel time to Three Rivers is about $2^1/_2$ hr.

In addition, a tour has been arranged to the Rolland Paper Co., Ltd., in St. Jerome, Que., where fine papers are made. Transportation to St. Jerome from Montreal may be arranged if there is a need. St. Jerome is just an hour's drive from Montreal.

The official visit of the conference will be made to the new laboratories of the Pulp and Paper Research Institute of Canada at Pointe Claire, a suburb of Montreal, on Thursday afternoon, August 17. Transportation will be arranged.

Those planning to attend the conference should write to

12th Testing Conference
Queen Elizabeth Hotel
Montreal, Quebec, Canada

and state both times and dates of arrival and departure.

Eleventh Corrugated Containers Conference

The Eleventh Corrugated Containers Conference is scheduled for Sept. 6–8, 1961, at the St. Francis Hotel in San Francisco, Calif. O. P. Wanamaker, Fibreboard Paper Products Corp., Antioch, Calif., technical program chairman, with the assistance of R. W. Catzen, Baltimore Paper Box Co., Baltimore, Md., G. M. Caploe, Longview Fibre Co., Oakland, Calif., and A. Richardson, Gaylord Container Div., Crown Zellerbach Corp., St. Louis, Mo., has arranged an interesting program. The program has been divided into three sections:

1. "Adaptation of Flexographic Printing to Corrugated" wherein the speakers will review the history of flexographic printing, will discuss equipment currently being manufactured for printing on corrugated and will discuss experiences of converters in producing and merchandising flexographic printed corrugated products.
2. "Use of Corrugated Containers in the Agricultural Field on the West Coast" wherein speakers will emphasize the design and end-use problems of containers for agricultural products and will also suggest some of the designs and techniques which may be applicable for other type products. It should be noted the plant tours have been arranged as a follow-up of the subjects discussed at this session.
3. "Engineering Developments" wherein the speakers will discuss a number of related engineering problems.

TENTATIVE PROGRAM

TUESDAY, SEPT. 5, 1961

9:00 a.m. Steering and Advisory Council (Mayfair Suite)
2:00 p.m. Engineering Committee (Olympic Suite South)
Industrial Engineering Committee (Olympic Suite North)
Process and Quality Control Committee (Oasis Room)
Production Committee (Davenport Suite)
Raw Materials Committee (Cosmopolitan Room)
3:00 p.m.–9:00 p.m. Registration (Mezzanine)

WEDNESDAY, SEPT. 6, 1961

8:00 a.m.–5:00 p.m. Registration (Mezzanine)
9:00 a.m. Opening Remarks (Colonial Ballroom)

O. P. Wanamaker,
Fibreboard Paper Products Corp.,
Antioch, Calif.

9:15 a.m. Session I (Colonial Ballroom)

"Adaptation of Flexographic Printing to Corrugated"

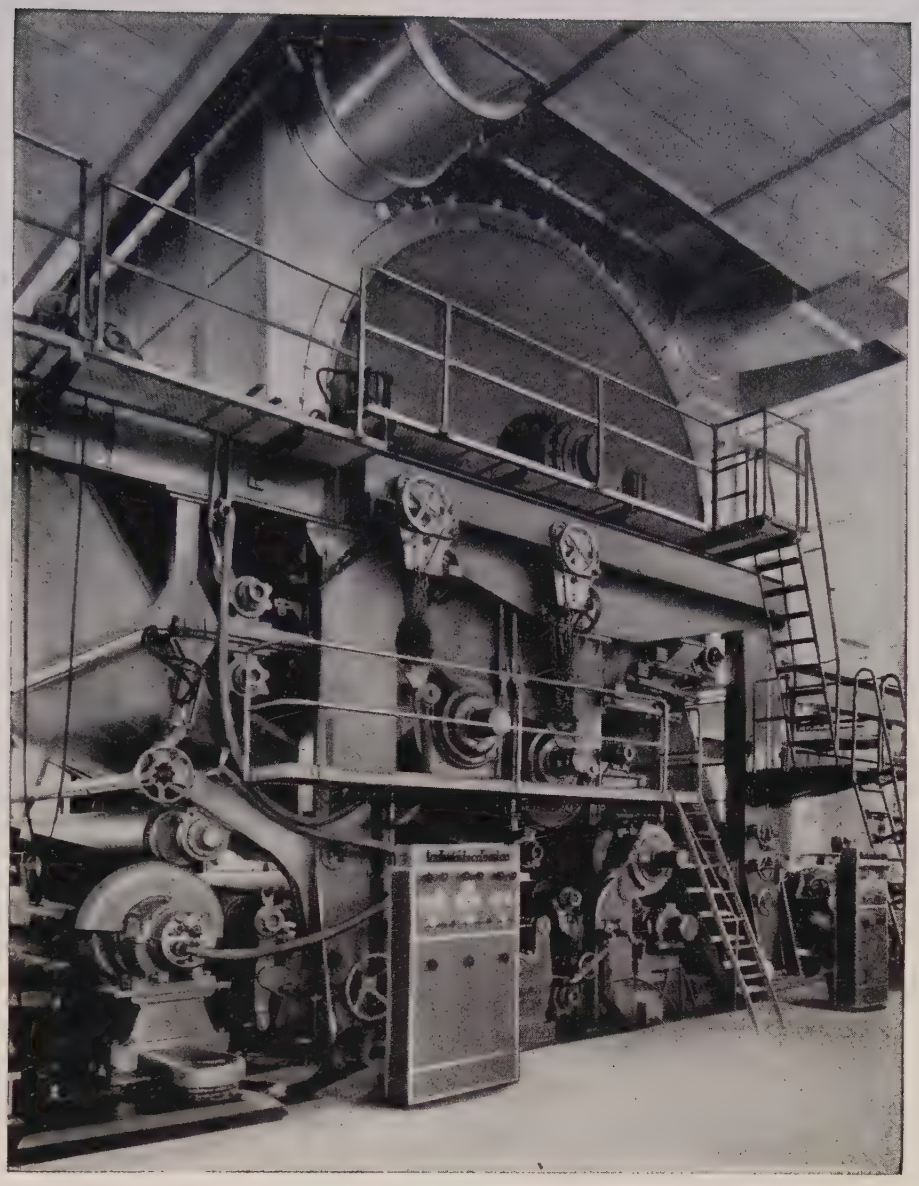
R. W. Catzen, Baltimore Paper Box Co., Baltimore, Md., *Moderator*

1. "Flexography," by D. E. Tuttle, International Printing Ink Co., New York, N. Y.
2. "Developments in Flexographic Printing Equipment," by H. Koliwicki, F. X. Hooper Div., Koppers Co., Glenarm, Md.; D. Ward, Greenwood Engineering Div., Langston Co., Baltimore, Md.; A. F. Shields, S. & S. Corrugated Paper Machinery Co., Brooklyn, N. Y.; W. J. Hottendorf, H. & C. Container Machinery Co., Sunnyvale, Calif.

12:30 p.m. Luncheon (California Room)
2:00 p.m. Session II (Colonial Ballroom)

"Adaptation of Flexographic Printing to Corrugated," (Continued)

3. "Operating Experiences of a Flexographic Printer Slotter," by C. Dornbush, Royal Container Div., Georgia Pacific Paper Co., San Francisco, Calif.
4. "Operating Experiences of Flexographic Printing Equipment," by (author to be announced), Greenwood Engineering Div., Langston Co., Baltimore, Md.



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5. Open discussion on flexographic printing

R. W. Catzen, Baltimore Paper Box Co., Baltimore, Md., *Moderator*

6:00 p.m.–7:00 p.m. Reception (Mural Room)

THURSDAY, SEPT. 7, 1961

8:00 a.m.–2:00 p.m. Registration (Mezzanine)
9:00 a.m. Session III (Colonial Ballroom)

"Use of Corrugated Containers in the Agricultural Field on the West Coast"

G. M. Caploe, Longview Fibre Co., Oakland, Calif., *Moderator*

6. "Field Requirements for Special Boxes," by O. P. Wanamaker, Fibreboard Paper Products Corp., Antioch, Calif.
7. "Manufacture of Wax Impregnated Containers," by D. S. Brown, Atlantic Refining Co., Philadelphia, Pa.
8. "Manufacturing Produce Containers," by D. B. Phillips, Longview Fibre Co., Longview, Wash.
9. "Testing of Special Containers," by R. Guillou, University of California, Berkeley, Calif.

12:30 p.m. Annual Luncheon (California Room)

J. J. Koenig, Gaylord Container Div., Crown Zellerbach Corp., St. Louis, Mo., *Toastmaster*

2:00 p.m. Session IV (Colonial Room)

"Engineering Developments"

A. Richardson, Crown Zellerbach Corp., St. Louis, Mo., *Moderator*

10. "Management's View of the Technical Field," by P. F. Paul, The Flintkote Co., Los Angeles, Calif.
11. "Rotary Die Cutting with a Serrated Knife," L. H. R. McGill, St. Regis Paper Co., Providence, R. I.
12. Small Packaged Steam Generators, R. D. Merrill, Stone Container Corp., Chicago, Ill.
13. "Expandable Polystyrene Foam Cushioning," Charles Kienzle, Koppers Co., Inc., Monaca, Pa.

5:00 p.m. Closing Remarks

J. J. Koenig, Gaylord Container Div., Crown Zellerbach Corp., St. Louis, Mo.

Attention is called to the fact meetings of the Engineering, Industrial Engineering, Production, Process and Quality Control, and Raw Materials Committees will take place Tuesday, Sept. 5, 1961.

Two very interesting plant tours have been arranged: (1) Longview Fibre Co. in Oakland, Calif., and (2) Royal Container Div., Georgia Pacific Paper Co. in Milbrae, Calif. The people taking the plant tour will not only see two fine corrugated container plants but will also see how containers are designed specifically for use in the agricultural field on the West Coast.

Those wishing hotel reservations should write to

11th Corrugated Containers Conference
St. Francis Hotel
San Francisco, Calif.

and state both dates and times of arrival and departure.

Bound Volume—Technical Section 1960 TAPPI

Each year the pages of the Technical Section of *Tappi* are accumulated and bound in a cloth cover as a single volume. These volumes are usually ordered by members in advance. There are some copies of the 1960 volume available at $5.00 per copy and may be obtained from the Technical Association of the Pulp and Paper Industry, 360 Lexington Ave., New York 17, N. Y.

Fourth International Mechanical Pulping Conference

The Mechanical Pulping Committees of the Technical Association of the Pulp and Paper Industry and the Technical Section of the Canadian Pulp and Paper Association are working together in the preparation of a program for the Fourth International Mechanical Pulping Conference, which will be held at the Edgewater Beach Hotel in Chicago on Sept. 19–21, 1961.

World-wide participation is indicated by some of the speakers expected at this Conference from Canada, England, Italy, Sweden, Germany, and the United States.

The highlights of the meeting will revolve around papers on fundamentals of grinding, chip groundwood, bleaching and new techniques for increasing capacity, and improving quality with existing grinder equipment.

A comprehensive review of new refining developments and current practices will take place, with particular emphasis on large-scale newsprint production. A complete session will be devoted to "The Layout of an Ideal Groundwood Mill," in which all attending will have the opportunity to participate.

Anyone connected with the preparation of mechanical pulp cannot afford to miss this important conference.

W. H. de Montmorency, Pulp and Paper Research Institute of Canada, Montreal, Que., is general chairman of the conference. S. R. Parsons, Consolidated Water Power and Paper Co., Wisconsin Rapids, Wis., is technical program chairman. Local arrangements are being handled by A. A. Yankowski, Irving Pulp & Paper Co., Ltd., and publicity is being handled by W. H. Copeland, Norton Co. of Canada, Hamilton, Ont.

T. F. La Haise, Ryegate Paper Co., East Ryegate, Vt. is chairman of the TAPPI Mechanical Pulping Committee and H. P. Richards, Ontario Paper Co., Thorold, Ont., is chairman of the Technical Section, CPPA Mechanical Pulping Committee.

TENTATIVE PROGRAM

MONDAY, SEPT. 18, 1961

11:00 a.m. Mechanical Pulping Committees—TAPPI and Technical Section CPPA (Parkview Room)
3:00–8:00 p.m. Registration (Passaggio)

TUESDAY, SEPT. 19, 1961

8:00 a.m.–4:00 p.m. Registration (Passaggio)
9:30 a.m. Session I (East Lounge)

Opening Remarks

W. H. de Montmorency, Pulp and Paper Research Institute of Canada, Montreal, Que., *Conference Chairman*

Fourth International Mechanical Pulping Conference Arrangements Committee: standing—R. A. Joss, A. J. Winchester, K. L. Pingrey, N. I. Robertson, and H. O. Teeple; seated—W. H. Copeland, S. R. Parsons, W. H. de Montmorency, and A. A. Yankowski

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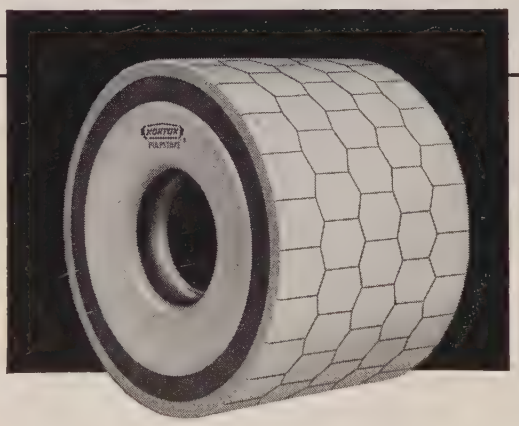
4th International MECHANICAL PULPING CONFERENCE

Edgewater Beach Hotel · Chicago, Illinois, U.S.A.
September 19, 20 and 21, 1961

Norton personnel from all over the world will be there to discuss the latest developments and techniques such as pitless grinding, higher speeds, and in general, how to get the most out of your present equipment.

This conference, jointly sponsored by the Technical Association of the Pulp & Paper Industry, and the Technical Section — Canadian Pulp & Paper Association, will again feature formal papers, round table discussions and new ideas on the production of mechanical pulp.

For the fourth time, a broad range of topics has been selected with authorities from Canada, Germany, Italy and Sweden, among others, scheduled as speakers.



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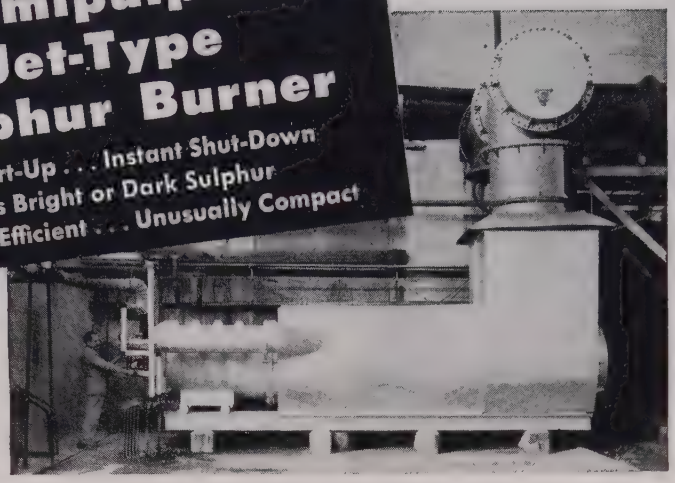

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Keynote Address:

LOWELL BESLEY, Pulp and Paper Research Institute of Canada, Montreal, Que.

10:30 a.m.

1. "Mechanical Pulping Studies with a Model Steel Wheel," by D. Atack, Pulp & Paper Research Institute of Canada, Montreal, Que.
2. "Heat Production and Dissipation in the Grinding Zone of the Wood Grinder," by B. Steenberg and A. Nordstrand, Swedish Forest Products Research Laboratory, Paper Technology Department, Stockholm, Sweden

2:00 p.m. ***Session II (East Lounge)***

3. "Energy Consumption in Mechanical Pulping," by G. E. R. Lamb, State University of New York, College of Forestry, Syracuse, N. Y.

3:00 p.m.

4. "The Influence of Groundwood Quality on Surface Smoothness and Printability of Paper," by Otto Brauns, Pappersbrukens Centrallaboratorium, Stockholm, Sweden
5. "Comparison of Intermittent and Continuous Grinders," by W. Brecht, Institute fur Papierfabrikation, Der Technischen Hochschule Darmstadt, Darmstadt, West Germany and F. Luhde, Anglo Paper Products, Ltd., Quebec, Que.

WEDNESDAY, SEPT. 20, 1961

8:00 a.m.–4:00 p.m. ***Registration (Passaggio)***
9:00 a.m. ***Session III (East Lounge)***

6. "The Development and Production of Disk Refiner Groundwood Pulp," by W. F. Holzer, J. T. Henderson, W. B. West, and K. F. Byington, Crown Zellerbach Corp., San Francisco, Calif.

10:45 a.m.

7. "Mechanical Pulp by Refining of Hardwood and Softwood Chips," by R. M. Dorland, Abitibi Power and Paper Co., Ltd., Sault St. Marie, Ont.

2:00 p.m. ***Session IV (East Lounge)***

8. "Cold Caustic Pulp from Single-Stage Refining," by V. B. Bodenheimer, Continental Can Co., Augusta, Ga.
9. Panel Discussion: "Mechanical Pulp from Chips"

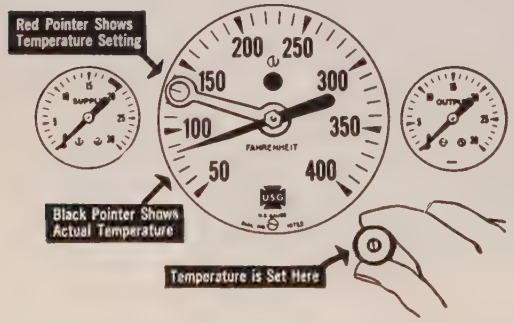
Panel Members: J. H. Fisher, MacMillan & Bloedel and Powell River, Ltd., Nanaimo, B. C.; J. E. Foote, Diamond National Corp., Stamford, Conn.; K. C. Logan, Anglo Paper Products, Ltd., Quebec, Que.; J. N. Swartz, Bowaters Southern Paper Corp., Calhoun, Tenn.; P. E. Trout, Waldorf Paper Prod., St. Paul, Minn.

3:45 p.m. ***Panel Discussion, continued (East Lounge)***
6:00 p.m. ***Suppliers' Reception (East Lounge)***
7:30 p.m. ***Banquet (Ballroom)***

Toastmaster: W. H. DE MONTMORENCY, Pulp and Paper Research Institute of Canada, Montreal, Que. *Conference Chairman*

Speaker: ROBERT K. BURNS, Assoc. Dean of Graduate School of Business and Executive Director of Industrial Relations Center, University of Chicago, Chicago, Ill.

New control maintains best temperature in each wet end dryer



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9:30 p.m. ***Dance (East Lounge)***

THURSDAY, SEPT. 21, 1961

8:00 a.m.–2:00 p.m. ***Registration (Passaggio)***
9:00 a.m. ***Session V (East Lounge)***

10. "Bersano Grinding Process," by Piero Bersano, Cartiere Burgo, Torino, Italy

10:45 a.m.

11. Panel Discussion: "Grinder Operation Breakthrough"

Panel Members: C. Anker, Risor Tremassefabriker, Risor, Norway; J. W. Griffin, Great Northern Paper Co., Millinocket, Me.; R. Murley, Bowaters Newfoundland Pulp and Paper Co., Ltd., Cornerbrook, Nfld.; H. P. Richards, The Ontario Paper Co., Ltd., Thorold, Ont.; G. W. Thompson, Bowaters Research and Development Co., Ltd., London, England; H. J. Turmaine, Abitibi Power and Paper Co., Ltd., Port Arthur, Ont.

2:00 p.m. ***Session VI (East Lounge)***

12. "Relations of Groundwood Screening Procedures," by W. Brecht, Institut fur Papierfabrikation, Der Technischen Hochschule Darmstadt, Darmstadt, West Germany, and A. Weidhaas
13. "High Density Groundwood Bleaching," by D. M. Ferguson, St. Regis Paper Co., Deferiet, N. Y.

3:30 p.m.

14. Panel Discussion: "Layout of an Ideal Groundwood Mill"

Panel Members: Representatives from newsprint, book, tissue, board, and custom groundwood mills

Sixth Deinking Conference

The Sixth Deinking Conference will be held Oct. 4–6, 1961, at the Hotel Harris in Kalamazoo, Mich. S. J. Stetz, Allied Paper Corp., Kalamazoo, Mich., has reported substantial progress in plans for the Conference. G. C. Sisler, Bergstrom Paper Co., Neenah, Wis., is technical program chairman and some of the topics to be presented are as follows:

"New Developments in Bleaching," by J. Schuber, Solvay Process Corp., Syracuse, N. Y.
"Economics of Bleaching," by P. J. Schmitt, P. H. Glatfelter Co., Spring Grove, Pa.
"Bleaching Deinked Stock," by G. H. Baldauf, Allied Paper Corp., Kalamazoo, Mich.
"Zinc Hydrosulfite," by R. W. Barton, Virginia Smelting Co., W. Norfolk, Va.
"Three-Stage Bleaching," by J. D. Allen, Bergstrom Paper Co., Neenah, Wis.
"Color Reversion," by A. H. Nadelman, Kalamazoo, Mich.

R. Bennett, Allied Paper Corp., Kalamazoo, Mich., plant tours chairman, has announced plant tours to Allied Paper Corp., King, and Bryant mills; and Pioneer Paper Stock Co. Another tour is also being planned.

A feature of the conference will be an address by J. D. Dailey, Sr., vice-president of Allied Paper Corp., Kalamazoo, Mich., at the banquet on Thursday, Oct. 5, 1961.

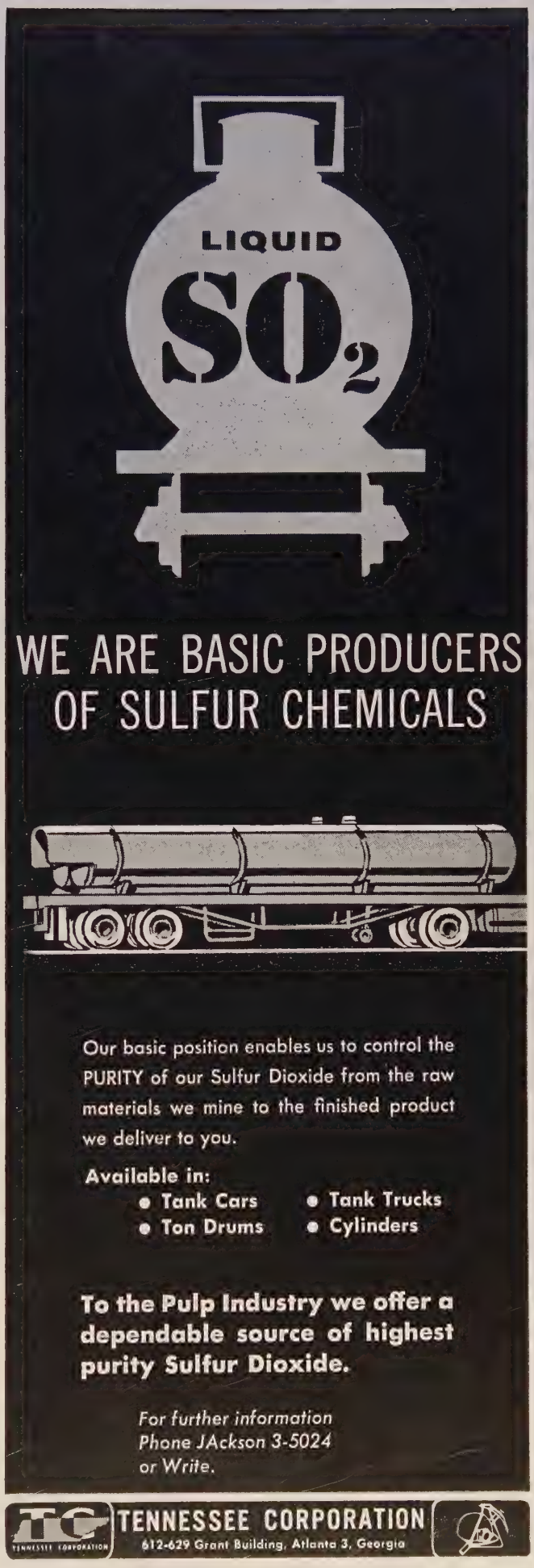
Those planning to attend the conference should write to:

6th Deinking Conference
Hotel Harris
Kalamazoo, Mich.

and state both times and dates of arrival and departure.

Bibliography of Paper Making—1960

Labels requesting this book were sent to all members. Any member desiring this publication who has not already notified the Association should write immediately or send in the filled-out label.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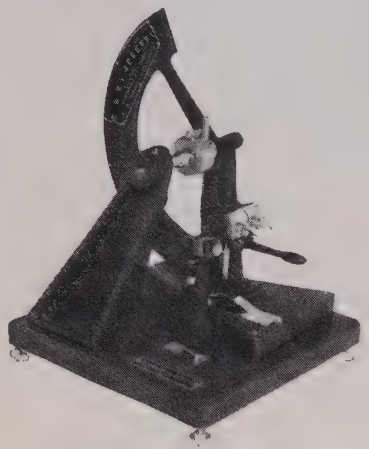

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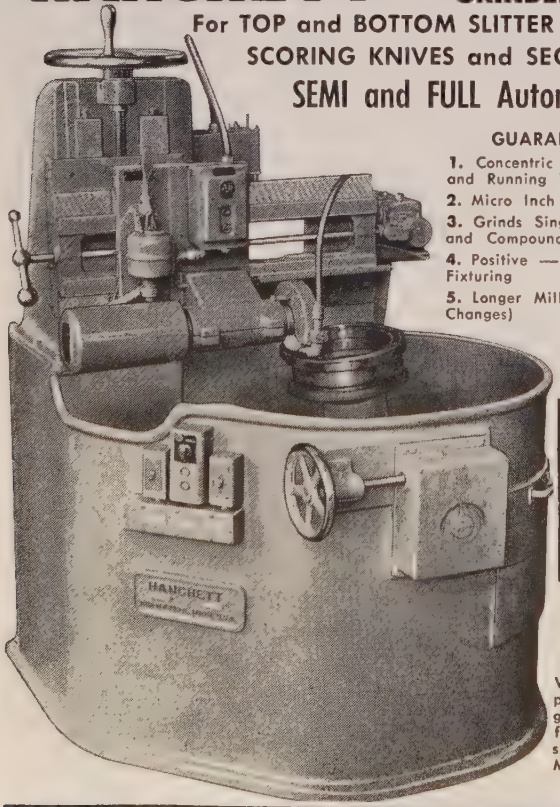

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Sixteenth Plastics-Paper Conference

The Sixteenth Plastics-Paper Conference is to be held Oct. 9–11, 1961, at the French Lick-Sheraton Hotel in French Lick, Ind.

R. W. Loheed, Chas. T. Main, Inc., Boston, Mass., is general conference chairman.

A fine technical program is being prepared by T. A. Howells, The Institute of Paper Chemistry, Appleton, Wis. The tentative program is as follows:

TENTATIVE PROGRAM

SUNDAY, OCT. 8, 1961

12:00–8:00 p.m. Registration (Lobby)
5:00 p.m. Division Officers Meeting (Parlor 107)

MONDAY, OCT. 9, 1961

8:00 a.m.–5:00 p.m. Registration (Lobby)
9:00 a.m. Session I—Plastics Committee Convention Hall

W. F. Nolan, Federal Paperboard Co., Bogota, N. J., *Chairman*

1. "Fundamentals of 'Flow' or 'Curtain' Coating," by W. Sandowski, Joyce Research & Development Corp., Valley Stream, Long Island, N. Y.
2. "Deinking of Plastics," by A. J. Felton, The Black Clawson Co., Shartle Div., Middletown, Ohio
3. "Polystyrene Foam Production," (author to be announced)
4. "Application and Properties Vinylidene Chloride Emulsion Polymers Applied to Paper," by R. F. Avgry, Organic Chemicals Research, W. R. Grace & Co., Cambridge, Mass.
5. "Blends of Ethylene/Vinyl Acetate Copolymers and Wax as Flexible Paper Coatings," by S. T. Lamar, R. H. Beeman, and E. P. Czerwin, E. I. du Pont de Nemours & Co., Inc., Chestnut Run Laboratory, Wilmington, Del.

2:00–3:30 p.m. Committee Meetings
Plastics Committee (Parlor "B")
Plastic Laminates Committee (Parlor "C")
Wet Strength and Interfiber Bonding Committee (Parlor "G")
4:00–5:30 p.m. Committee Meetings
Extrusion Coatings Committee (Parlor "B")
Synthetic Fiber Committee (Parlor "G")
Project—C.A. No. 803 (Parlor "F")
6:30 p.m. Reception (Convention Hall)
7:30 p.m. Banquet (West Dining Room)

Speaker: Dr. B. Golding, Department of Chemical Engineering Purdue University, Lafayette, Ind.

TUESDAY, OCT. 10, 1961

8:00 a.m.–5:00 p.m. Registration (Lobby)
9:00 a.m. Session II—Wet Strength and Interfiber Bonding (North Foyer)

C. S. Maxwell, Charles S. Maxwell, Old Greenwich, Conn., *Chairman*

1. "Alkaline-Curing Resins and Their Use in Paper," by G. I. Keim, Hercules Powder Co., Wilmington, Del.
2. "Wet-End Additions of Separated Cornstarch Fractions," by M. L. Cushing, A. E. Staley Manufacturing Co., Decatur, Ill.
3. "The Preparation and Properties of Paper crafted by Ceric Ion Technique," E. Schwab and V. T. Stannett, State University, College of Forestry, Syracuse, N. Y., D. H. Rakowitz and J. K. Magrane, American Cyanamid Co., Stamford, Conn.
4. "High Efficiency Wet Strength Production by Dialdehyde Starch in Closed White Water Systems," by G. E.

Hamarstrand, B. T. Hofreiter, U. S. Department of Agriculture, Peoria, Ill.

5. "Polyacrylamide as a Stock Additive," by W. F. Linke, American Cyanamid Co., Stamford, Conn.

9:00 a.m. Session III—Packaging Usage Paper-Plastics Materials (Convention Hall)

E. J. Kane, Thomas J. Lipton, Inc., Hoboken, N. J., *Chairman.*

1. "Package Usage," by E. M. Baltuff, Bemis Bag Co., Minneapolis, Minn.
2. "Paper-Plastic Uniforms," by G. Thomas, Quartermaster Research and Development Command, Natick, Mass.
3. "Beam Test for Wet Strength—Corrugated-Wax Impregnated," by D. Brown, Atlantic Refining Co., Philadelphia, Pa.
4. To be announced
5. To be announced

12:00 Noon. 1962 Conference Planning Meeting (Mural Room)

WEDNESDAY, OCT. 11, 1961

8:00 a.m.—5:00 p.m. Registration (Lobby)

9:00 a.m. Session IV—Plastics Laminate Committee (North Foyer)

R. Doughty, Fitchburg Paper Co., Fitchburg, Mass., *Chairman*

Papers to be announced

9:00 a.m. Session V—Synthetic Fibers Committee (Convention Hall)

R. A. A. Hentschel, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., *Chairman*

Panel Discussion: "The Growing Importance of Man-Made Fibers in the Paper Industry"

12:00 Noon Conference Luncheon (West Dining Room)

2:00 p.m. Session VI—Extrusion Coating Committee (Convention Hall)

J. S. Thornton, Frank W. Egan Co. Somerville, N. J., *Chairman*

Papers to be announced

French Lick, Ind., is approximately 100 miles from the Indianapolis, Ind., airport and approximately 65 miles from the Louisville, Ky., airport. In an effort to facilitate transportation to French Lick, the Local Arrangements Committee, under the chairmanship of C. E. Eberly, Paper Art Co., Inc., Indianapolis, Inc., has made arrangements for charter bus service departing from the Indianapolis Airport at specified times. A TAPPI lounge will be available within the airport terminal building to serve as a marshalling area to facilitate the loading of buses and to assure their prompt departure when loaded.

Charter bus service from French Lick to Indianapolis Airport will also be available after the conference, beginning Wednesday evening. Arrangements as to departure times will be made at the conference. Round trip fare from the Indianapolis Airport is $10.

For those who wish to fly to Louisville, Ky., charter plane service is available from nearby Bowman Field, Central American Airways (Phone Glendale 8-1161) or from Kentucky Air Transport (Phone Glendale 8-1521). In the latter case, the charge is $6.25 per person in groups of three.

Those wishing hotel reservations should write to

16th Plastics-Paper Conference
French Lick-Sheraton Hotel
French Lick, Ind.

and state both dates and times of arrival and departure. The French Lick-Sheraton teletype number is FL-471.

A modest ladies' program has been arranged and Tuesday afternoon has been left open for personal activities.

No plant tours are planned for this conference.

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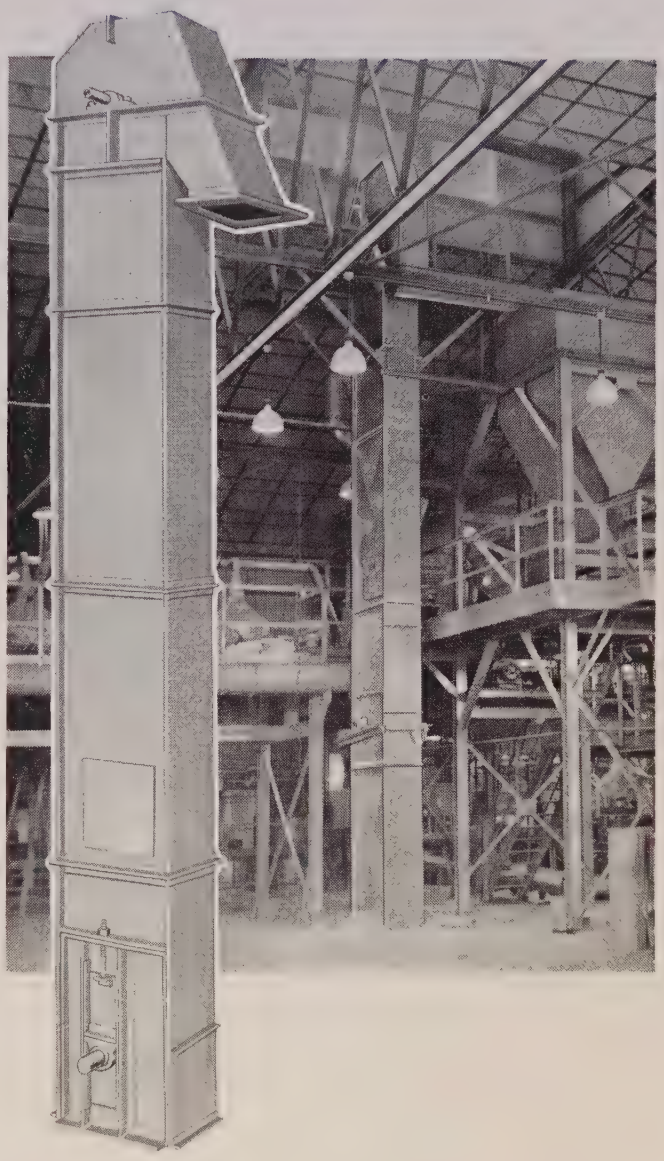

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Sixteenth Engineering Conference

The Sixteenth Engineering Conference, scheduled for Oct. 16–19, 1961, at the Shoreham Hotel in Washington, D. C., will place emphasis on the theme "Cost Reduction Through Engineering." B. R. Cancell, executive vice-president of St. Regis Paper Co., New York, N. Y., will deliver an address on the conference theme during the opening session on Monday, October 16.

The technical program has been arranged to reflect the theme and will consist of 18 sessions and some 60 papers. The program, subject to a few changes is as follows:

SUNDAY, OCT. 15, 1961

3:00 p.m.–5:00 p.m. Engineering Division (Park Room)

Committee Officers Meeting

12:00 p.m.–8:00 p.m. Registration (West Lobby Foyer)

MONDAY, OCT. 16, 1961

8:00 a.m.–5:00 p.m. Registration (West Lobby Foyer)
7:30 a.m.–8:30 a.m. Authors' Breakfasts

Sanitary Engineering (North Room)
Corrosion (South Room)
Industrial Engineering (East Room)
Drying (Lower West Room)

9:00 a.m.–9:30 a.m. First Session (West Ball Room)

Conf. Opening Address: B. R. Cancell, Executive V. P., St. Regis Paper Co., New York, N. Y.

9:30 a.m.–12:30 p.m. Second Session—Corrosion I (Terrace Room)

E. W. Hopper, Pittsburgh, Pa., *Chairman*

2-1. "A New Design for a Reinforced Plastic Tank," by C. D. Hayden, Hayden Wire Works, W. Springfield, Mass.
2-2. "Inspection of Process Equipment Fabrication," by C. Eldridge, Inspection & Consulting, Service, Palgrave, Ont.
2-3. "Project 839 Report—Corrosion in ClO_2 Bleaching," by R. E. L. Wheless, Union Bag-Camp Corp., Franklin, Va.

9:30 a.m.–12:30 p.m. Third Session—Industrial Engineering (West Ball Room)

B. C. Kendall, Crown Zellerbach Corp., San Francisco, Calif., *Chairman*

3-1. "Outdoor Storage and Handling of Wood Chips on the West Coast," by M. W. Burke, Crown Zellerbach Corp., Antioch, Calif.
3-2. "Outdoor Storage and Handling of Wood Chips in South and East," by J. Holekamp, American Pulp Wood Assn., Sylacauga, Ala.
3-3. "Wood Procurement and Harvesting," by T. Baker, St. Regis Paper Co., Jacksonville, Fla.
3-4. "Wood Storage and Handling in Woodyards," by J. R. Girardeau, Brunswick Pulp & Paper Co., Brunswick, Ga.

2:15 p.m.–5:15 p.m. Fourth Session—Corrosion II (Terrace Room)

H. B. Harris, Union Bag-Camp Paper Corp., Savannah, Ga., *Chairman*

4-1. "Project 522 Report—Regional Report on Alkaline Digester Corrosion," by H. M. Canavan, Mutual Boiler and Machine Inspection Co., Waltham, Mass.
4-2. "Successful Stainless Steel Overlay Installation," by Z. S. Blanchard, Chicago Bridge & Iron Co., Portland, Me., and P. C. Bobo, Mead Corp., Kingsport, Tenn.
4-3. Panel Discussion—Recommendation on Stainless Steel Overlay Installation; R. C. Stamm, Moderator, West Virginia Pulp & Paper Co., New York, N. Y.

2:15 p.m.–5:15 p.m. Fifth Session—Drying (West Ball Room)

F. G. Perry, Arthur D. Little, Inc., Cambridge, Mass., *Chairman*

5-1. "Heat Transfer and Water Removal in Cylinder Drying—Felted Cylinders," by A. H. Nissan and H. George, Rensselaer Polytechnic Institute, Troy, N. Y.
5-2. "A Review of High Velocity Drier Installations and Some Studies of Wet Pressing," by J. A. Means, Time, Inc., Springdale, Conn.
5-3. "High Velocity Drier Experience," by J. Villalobos, J. O. Ross Engineering Co., New York, N. Y.

B. R. Cancell, St. Regis Paper Co., who will give the opening address at the conference

2:15 p.m.–5:15 p.m. Sixth Session—Sanitary I (Main Ball Room)

W. A. Moggio, Armstrong Cork Co., Lancaster, Pa., *Chairman*

6-1. "Waste Treatment," by C. S. Huestis, Continental Can Co., New York, N. Y.
6-2. "Waste Treatment," by W. D. Rice, P. H. Glatfelter Co., Spring Grove, Pa., and R. F. Weston, R. F. Weston, Inc., Newtown Square, Pa.
6-3. Waste Treatment," by G. M. Griffith, West Virginia Pulp & Paper Co., Luke, Md.
6-4. "Waste Treatment," by H. C. Koch, Weston Paper & Mfg. Co., St. Mary's, Ohio

TUESDAY, OCT. 17, 1961

8:00 a.m.–5:00 p.m. Registration (West Lobby Foyer)
7:30 a.m.–8:30 a.m. Authors' Breakfasts

Sanitary Engineering (North Room), Engineering Economics (South Room), Chemical (West Room)

9:00 a.m.–12:00 p.m. Seventh Session—Sanitary II (Main Ball Room)

R. W. Simpson, Gilbert Associates, Inc., Reading, Pa., *Chairman*

7-1. "Waste Treatment," by L. L. Klinger, Whippany Paper Board Co., Whippan, N. J.
7-2. "Waste Treatment," by W. F. Fields, Armstrong Cork Co., Lancaster, Pa., and T. W. Lewis, Jr., Armstrong Cork Co., Pensacola, Fla.
7-3. Panel Discussion—Waste Treatment: W. G. Moggio, Moderator, Armstrong Cork Co., Lancaster, Pa.

9:00 a.m.–12:00 p.m. Eighth Session—Engineering Economics (Terrace Room)

G. W. Sargent, Beloit Iron Works, Beloit, Wis., *Chairman*

8-1. "Determining the Best Facilities for a Company's Needs," (Author to be announced)
8-2. "Economic Considerations in Design of Plant Structures," by S. D. Srite and E. E. Townsend, Engineering and Development, Inc., Calhoun, Tenn.

9:00 a.m.–12:00 p.m. Ninth Session—Chemical Engineering (West Ball Room)

A. W. Plummer, S. D. Warren, G. Cumberland Mills, Me., *Chairman*

9-1. "Operational Experience and Economics of Several Large Heat Recovery Systems," by N. O. Alm, Aktiebologet Separator Co., Lund, Sweden

9-2. To be announced
9-3. To be announced
9-4. "Gas Adsorption," by S. T. Han and C. Spaudling, The Institute of Paper Chemistry, Appleton, Wis.

12:30 p.m. Committee Luncheons

Sanitary Engineering (North Room)
Industrial Engineering (South Room)
Corrosion (Club Room)
Chemical Engineering (West Room)

WEDNESDAY, OCT. 18, 1961

8:00 a.m.–5:00 p.m. Registration (West Lobby Foyer)
7:30 a.m.–8:30 a.m. Authors' Breakfasts

Process Instrumentation (North Room)
Steam and Power (Park Room)
Fluid Mechanics (Club Room)
Operations Research (West Room)

9:00 a.m.–12:00 p.m. Tenth Session—Process Instrumentation (Terrace Room)

E. W. Prince, Champion Paper and Fibre Co., Hamilton, Ohio, *Chairman*

10-1. "Controlling the Variables," by W. A. Wrase, S. D. Warren Co., Muskegon, Mich.
10-2. "Recovery Unit Control," by H. Couture, East Texas Pulp & Paper Co., Evadale, Tex.
10-3. Project 692 Report—Organization and Importance of Paper Mill Instrument Department
10-4. Panel Discussion—Data Handling Systems: D. P. Michel, moderator, Bauer Bros Co., Springfield, Ohio

9:00 a.m.–12:00 p.m. Eleventh Session—Fluid Mechanics I (West Ball Room)

C. A. Lee, Formex Co., Div. of F. C. Huyck & Sons, Knoxville, Tenn., *Chairman*

11-1. "The Initial Retention of Fibers by Wire Grids," by R. Estridge, Albemarle Paper Manufacturing Co., Richmond, Va.
11-2. "Drainage in a Suction Former," by S. T. Han, The Institute of Paper Chemistry, Appleton, Wis.
11-3. "A Filtration Theory for Fibrous Mats Formed From Dilute Suspensions," by H. Meyer, Mead Corp., Chillicothe, Ohio.
11-4. "The Capillary Behavior of Paper," R. E. White, Villanova University, Villanova, Pa., and W. E. Marceau, Selas Corp., Dreshertown, Pa.
11-5. "The Influence of Suspended Material on Turbulence" (Report on TAPPI Project 715-PA192), by J. W. Daily and T. K. Chu, Massachusetts Inst. of Technology, Cambridge, Mass.

12:30 p.m.–2:00 p.m. Committee Luncheons

Construction Engineering (South Room)
Electrical Engineering (Park Room)
Fluid Mechanics (Club Room)

2:00 p.m.–5:00 p.m. Twelfth Session—Fluid Mechanics II (West Ball Room)

P. E. Wrist, Mead Corp., Chillicothe, Ohio, *Vice-Chairman*

12-1. "The Cause of Post Table-roll Instability of Stock on the Fourdrinier Wire," by C. S. Yih and W. R. Debler, College of Engineering, University of Michigan, Ann Arbor, Mich.
12-2. "Instability of a Rotating Liquid Film," by C. S. Yih, College of Engineering, University of Michigan, Ann Arbor, Mich.
12-3. "Theoretical Considerations of Vortex Separators," by J. D. Boadway, Consolidated Paper Corp., Grand Mere, P.Q., Canada.
12-4. "Hydrodynamics of Paper Machine Headbox Manifold or Distribution Systems," by J. Mardon, D. W. Manson, and J. E. Wilder, Oxford Paper Co., Rumford, Me.
12-5. "The Behavior of Two Dimensional Slice Jets," by J. J. Stukel and G. L. Calehuff, West Virginia Pulp & Paper Co., Covington, Va.

2:00 p.m.–5:00 p.m. Thirteenth Session—Steam and Power (Terrace Room)

H. R. Emery, St. Regis Paper Co., Jacksonville, Fla., *Chairman*

13-1. "Economics of One Large versus Two Half Size Turbine Generators for Paper Mill Power Plants," by T. J. Judge, International Paper Co., Mobile, Ala.
13-2. "Centralized Control of Steam and Electric Power in Pulp & Paper Mills," by R. E. Crossley, Great Northern Paper Co., Millinocket, Me.
13-3. Panel Discussion—Projected Thinking on Design of Paper Mill Power Plants: P. L. Nelson, moderator, Chas. T. Main, Inc., Boston, Mass.

2:00 p.m.–5:00 p.m. Fourteenth Session—Operations Research (Main Ball Room)

E. F. Thode, The Institute of Paper Chemistry, Appleton, Wis., *Chairman*

14-1. "The Methods, Value, and Roll of Practice Operations Research in Industry," by E. A. Johnson, Johns Hopkins University, Baltimore, Md.
14-2. To be announced
14-3. To be announced
14-4. To be announced

6:00 p.m.–7:00 p.m. Cocktail Hour (West Ball Room)
7:00 p.m. Banquet (Main Ball Room)

Toastmaster: M. J. Osborne, Bowaters Southern Paper Corp., Calhoun, Tenn., *Division Chairman*
Speaker: James E. Webb, National Aeronautics and Space Administration, Washington, D. C.

9:30 p.m. Dance (Terrace Room)

THURSDAY, OCT. 19, 1961

8:00 a.m.–10:00 a.m. Registration (West Lobby Foyer)
7:30 a.m.–8:30 a.m. Authors' Breakfasts

Electrical Engineering (North Room)
Construction Engineering (South Room)
Maintenance Engineering (Park Room)
Mechanical Engineering (West Room)

9:00 a.m.–12:00 p.m. Fifteenth Session—Mechanical Engineering (Terrace Room)

J. S. Mudgett, Strathmore Paper Co., West Springfield, Mass., *Chairman*

15-1. "Design and Paper Machine Application of Formex Fabric on Fourdrinier Machines," by J. W. Shearer, J. R. Wagner, Formex Co., Div. of F. C. Huyck & Sons, Knoxville, Tenn., and W. R. Givin, Huyck Equipment Co., New York, N. Y.
15-2. "Application of the Roll-less Flovac on a Fourdrinier Machine," by R. J. Smith, West Virginia Pulp & Paper Co., Covington, Va.
15-3. Panel Discussion—Mechanical Features of Continuous Digester Systems: R. T. DePan, Moderator, H. K. Ferguson Co., Cleveland, Ohio

9:00 a.m.–12:00 p.m. Sixteenth Session—Construction Engineering (West Ball Room)

W. Pittam, Stone & Webster Engineering Corp., San Francisco, Calif., *Chairman*

16-1. To be announced
16-2. To be announced
16-3. Panel Discussion—Construction Problems: W. Pittam, Moderator, Stone & Webster Engineering Corp., San Francisco, Calif.

12:30 p.m.—2:00 p.m. Committee Luncheon

Steam and Power (Park Room)

2:00 p.m.–5:00 p.m. Seventeenth Session—Electrical Engineering (Terrace Room)

S. Andersen, West Virginia Pulp and Paper Co., New York, N. Y., *Chairman*

17-1. "Proper Application of Motor Control Centers in Paper Mills," by L. D. Mower, C. T. Main, Inc., Boston, Mass.

17-2. "Power Requirements for Tissue Machines—Project 622 Report," (by title) by C. C. Collins, General Electric Co., Schenectady, N. Y.

17-3. "Comparison of Types of Reel Drives for Converting Equipment," by R. J. Minges, Diamond National Corp., Middletown, Ohio

17-4. "Equipment Grounding for Safety," by J. V. Cundelan, Rayonier, Inc., New York, N. Y., and E. C. Benjamin, M. W. Kellogg Co., New York, N. Y.

17-5. "Project 866 Interim Report—Field Experience with Sealed Motor Insulation Systems," by L. W. Porter, St. Joe Paper Co., Port St. Joe, Fla.

2:00 p.m.–5:00 p.m. Eighteenth Session—Maintenance Engineering (West Ball Room)

H. M. Reed, Jr., International Paper Co., Mobile, Ala., *Chairman*

18-1. "Measuring Maintenance Efficiency," by C. L. Clarke, H. B. Maynard Co., New York, N. Y.

18-2. "Materials for Recovery Dissolving Tank Construction," by J. J. Yirak, Union Bag-Camp Paper Corp., Savannah, Ga.

18-3. Industry Maintenance Practice Survey Report and Panel Discussion: H. W. Smith, Moderator, St. Regis Paper Co., Pensacola, Fla.

6:00 p.m.–8:30 p.m. Engineering Division Officers and Committee Officers Dinner and Meeting (Park Room)

An outstanding event of the conference will be an address at the banquet on Wednesday, October 18, by James E. Webb, Administrator of the National Aeronautics and Space Administration.

Mr. Webb was unanimously and enthusiastically approved as the new head of the National Aeronautics and Space Administration in February of this year. A native of North Carolina, he attended the University of North Carolina and George Washington University Law School in Washington, D. C. He is possibly best remembered as Director of the Budget Bureau from 1946–49, under the Truman Administration, and as Under-Secretary of State from 1949 until 1952.

When not in government service, Mr. Webb has pursued his law and business interests. As president of Educational Services, Inc., a nonprofit group, he has dedicated much of his time to improving science teaching in our high schools.

A modest ladies' program is being arranged by Mrs. William Allmond which will include a tour to Mt. Vernon with lunch and short side trips in historical Alexandria. There will also be a dance after the Wednesday evening banquet.

Tuesday afternoon has been left open, except for some committee meetings, to permit people attending the conference to visit Washington, D. C.

Those planning to attend the conference should write to:

16th Engineering Conference
Shoreham Hotel
Washington, D. C.

and state both times and dates of arrival and departure.

Fifteenth Alkaline Pulping Conference

The Fifteenth Alkaline Pulping Conference will be held Nov. 1–3, 1961, at the Rice Hotel in Houston, Tex. The general conference chairman is D. Wetherhorn, W. C. Davis Associates, Savannah, Ga.

As in previous years, there will be three sessions on alkaline pulping and T. T. Collins, Packaging Corp. of America, American Box Board Div., Filer City, Mich., is arranging a comprehensive program for the alkaline pulping sessions. The fourth session of the two-day meeting will be devoted to papers on sulfite pulping and E. D. Cann, Chas. T. Main, Inc., Boston, Mass., is arranging an interesting group of papers on sulfite pulping.

J. O. Parrott, Champion Paper and Fibre Co., Pasadena, Tex., is local arrangements chairman and he is arranging the mill tours which will include the Champion mill at Pasadena.

Those planning to attend the conference should write to:

15th Alkaline Pulping Conference
Rice Hotel
Houston, Tex.

and state both times and dates of arrival and departure.

Twelfth Coating Conference

The Twelfth Coating Conference of the Technical Association of the Pulp and Paper Industry was held May 8–10, 1961, at the Statler-Hilton Hotel, Buffalo, N. Y. This annual conference is sponsored by the TAPPI Coating Committee, Coating and Graphic Arts Division. R. T. Trelfa, Perkins-Goodwin Co., New York, N. Y., and C. G. Landes, North Carolina State College, Raleigh, N. C., are chairmen of the sponsoring Division and Committee respectively.

The attendance of 925 conferees was slightly under that of the 1960 Coating Conference. However, this continues to be the largest of all TAPPI functional conferences.

The 1961 conference was planned by the following committee under the general chairmanship of R. W. Martinek, Kimberly-Clark Corp., Neenah, Wis.

C. G. Whelpton, The Champion Paper & Fibre Co., Hamilton, Ohio, program chairman.
W. E. Welliver, Minerals & Chemicals Philipp Corp., Menlo Park, N. J., publicity chairman.
C. E. Mikel, Corn Products Co., Buffalo, N. Y., local arrangements chairman.

Program Committee

R. I. Bashford, Jr., Penick & Ford Ltd., Inc., Cedar Rapids, Ia.
J. E. Chinn, Bowaters Carolina Corp., Catawba, S. C.
J. T. Goodwin, Jr., Corn Industries Research Foundation, Inc., Washington, D. C.

Local arrangements committee—rear row: J. J. Lynch, Corn Products Co.; G. C. Inskeep, St. Regis Paper Co.; Frank A. Nilles, Nalco Chemical Co.; and D. Norton, The Hubinger Co. Front row: R. S. Buckley, Lockport Felt Co.; W. I. Arnold, International Paper Co.; C. G. Whelpton, Champion Paper & Fibre Co.; R. W. Martinek, Kimberly-Clark Corp.; C. E. Mikel, Corn Products Co.; and S. F. M. Maclaren, Penick & Ford Ltd., Inc. Missing from picture, C. O. Martin, Georgia Kaolin Co.

Thirteenth Coating Conference Program Committee—W. E. Welliver, Minerals & Chemicals Phillip Corp. program chairman

H. H. Lavery, International Paper Co., Corinth, N. Y.
E. R. Padavic, Container Corp. of America, Santa Clara, Calif.
M. Stiles, Time, Inc., Springdale, Conn.
C. W. Cairns, Dow Chemical Co., Detroit, Mich.
L. A. Gilbertson, Marathon Corp., Menasha, Wis.
N. W. Neubauer, Crown Zellerbach Corp., Camas, Wash.
G. E. Hall, Jr., Wyandotte Chemical Corp., Wyandotte, Mich.
P. W. Plante, St. Regis Paper Co., Deferiet, N. Y.
J. D. Wethern, Riegel Paper Corp., Acme, N. C.

LOCAL ARRANGEMENTS COMMITTEE

W. I. Arnold, International Paper Co., N. Tonawanda, N. Y., Registration & Hospitality chairman
R. S. Buckley, Lockport Felt Company, Newfane, N. Y., Plant Tours chairman
S. F. M. Maclaren, Penick & Ford Ltd., Inc., Buffalo, N. Y., Hotel Arrangements chairman

The developed program included five half-day technical sessions, a panel symposium the Annual Luncheon, and four plant tours. The afternoon of Tuesday, May 9, was devoted largely to subcommittee meetings with the annual Coating Committee meeting being held on Wednesday morning.

In the following report, brief abstracts of the papers are given. The full test of all the papers will appear in the various issues of *Tappi*.

First Session

Following an Author's Breakfast at 7:30 a.m., the conference was opened on Monday, May 8, 1961, by R. W. Martinek, general conference chairman. The meeting was then turned over to J. T. Goodwin, Jr., Corn Industries Research Foundation, Inc., Washington, D. C., who was chairman of the first technical session. Abstracts of the four papers presented are given below.

"Adhesion to Fibrous Materials," by J. J. Bikerman, Massachusetts Institute of Technology, Cambridge, Mass. Adhesion of coatings or glues to fibrous materials usually is a mechnical ("hooking") effect. This is proved, for instance, by the insensitivity of the bond to impurities causing weak boundary layers. The experiment allegedly proving the existence of specific adhesion between glue and fiber can be given a better explanation. In those instances in which no hooking and no embedding occur, the adhesion to fibrous materials is analogous to the adhesion to nonporous solids.

The rate of formation and setting of adhesive joints with fibrous adherends is determined by the shape and size of pores in the adherends, their wettability and their tendency to swell, and by the viscosity (or consistency) and the surface tension of the adhesive. These relations can be expressed in quantitative terms.

"Some Theoretical Aspects of Adhesion," by T. Alfrey, Jr., Dow Chemical Co., Midland, Mich. The effective adherence of one solid to another depends not only upon the intermolecular forces acting at the interface, but also upon geometrical factors which control the multiaxial stresses in the two media. Of particular interest is the case of a very thin layer of one material adhering to a subtrate, or sandwiched between two substrates. In this case, encountered with surface coatings and adhesives, the geometrical factors can be of decisive importance, the consequences can be favorable or unfavorable with regard to overall performance of the composite structure. Thus a weak adhesive material may yield a strong joint, or vice versa. General principles and particular examples were discussed.

"Future Coating Trends," by M. R. Castagne, *Pulp & Paper*, New York, N. Y. Results of a survey on future coating trends were presented. Based upon a questionnaire sent to some 50 coatings experts, projections were made on future developments in coated paper and paperboard capacity, grades which have the greatest growth potential, coating, equipment, techniques, formulas, pigments, and adhesives.

Coated paper and paperboard: coated grades which have the greatest potential were discussed as well as grades, now uncoated, which may be coated in the future. Estimates of future capacity were presented for the years 1965, 1970, 1980, and 2000.

Coating equipment: major coating tools of the Sixties were discussed: The trailing blade coater and how it may be modified. On-machine cast coating and gloss calendering were compared as to their future potentials.

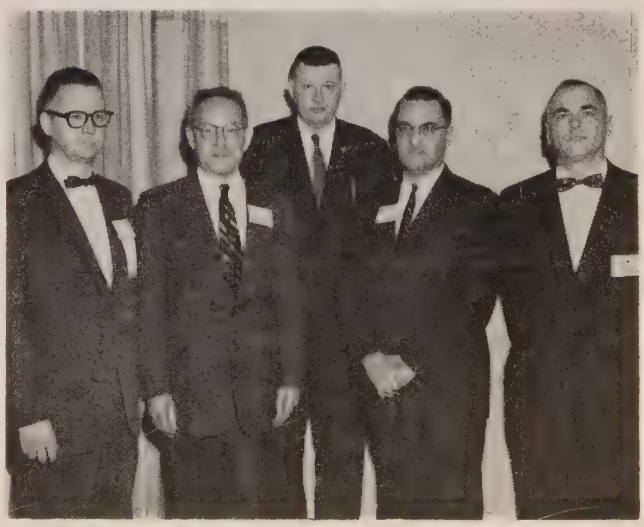
Coating pigments and adhesives: changes in types of pigments were discussed. Types of pigments which will be comers; what the industry seeks in the perfect pigment; what qualities will have priorities in pigments in the next 10 years. What role synthetics will play and why.

Coating formulas: how much further can the base stock be reduced in weight. What is the "ideal" coating base weigh for publication papers, for paperboard grades. How much further can coat weight and base stock be reduced.

Coating techniques: some pros and cons for on-machine and off-machine coating were presented.

World coating developments and trends: the author presented some data on present coating developments in Europe and how they may be expected to develop.

"Precast Clay Coating—A New Process and Product,"



First Session—J. T. Goodwin, Jr., Corn Industries Research Foundation, Inc.; J. J. Bikerman, Massachusetts Institute of Technology; T. Alfrey, Jr., Dow Chemical Co., M. R. Castagne, Pulp & Paper; F. D. Bergstein, Interstate Folding Box Co., Middletown, Ohio

by F. D. Bergstein, Interstate Folding Box Co., Middletown, Ohio. In this new process, a clay/adhesive composition is applied to a metal surface, dried, and then transferred intact onto the base sheet which has been first coated with a film of adhesive.

The process has many advantages including fast drying, simplicity, adaptability to on or off machine coating, and ability to coat a wide variety of base stocks.

And the end product has many advantages, including high brightness, outstanding gloss, excellent printability, excellent nonfade properties, and adaptability to colors.

This program involved extensive research over many years and the new precast coating process and product are fully covered by U. S. pat. 2,934,467 and other patents pending.

A 46-in. coater designed and built in Interstate Folding Box Co.'s machine shop to perform this precast method has now been in operation for a number of years.

A new 100-in. on-machine precast clay coater, built for us by the Dilts Division of The Black-Clawson Co. under license agreement and designed in cooperation with our personnel, is now starting up which can coat the full range of widths and grades from 0.015 to 0.036 and over, and which is believed to be the world's first on-machine cast coating operation.

Second Session

A. W. Neubauer, Crown Zellerbach Corp., Camas, Wash., was chairman of the second session, held on Monday afternoon, May 8th. Abstracts of the five papers presented during this period follow.

"Some Techniques for the Assessment of Coated Art Papers," by I. F. Hendry, Wiggins Teape Research and Development, Ltd., Beaconsfield, Bucks, England. The quality of high grade coated art papers is such that it is not possible to make sudden outstanding improvements. Small improvements are often not confirmed by commercial printing trials because of variability in the printing. If a program of research into coated art paper is to succeed, however, small improvements must be detected in order that they can be recognized. The techniques of surface measurement of the sheet and of controlled printing, described in this report, have enabled such small improvements to be perceived. These techniques involve the use of conventional smoothness testers and gloss meters, and also the use of a high sensitivity surface profile instrument, the I.G.T. printability tester, and an instrumented Vandercook proof press. To use the proof properly a scheme of print evaluation with a sufficiently high

Second Session—A. W. Neubauer, Crown Zellerbach Corp.; J. A. S. Newman, Wiggins Teape Research & Development, Ltd.; M. Judt, Feldmuhle Papier-und Zellstoffwerke Aktiengesellschaft, A. Harsveldt, Nationale Zetmeelindustrie, N. V.; J. F. Hern, Nopco Chemical Co.; and E. J. Heiser, The Dow Chemical Co.

Coating committee council—C. G. Landes, North Carolina State College; A. J. Winchester, TAPPI; R. W. Martinek, Kimberly-Clark Corp.; R. W. Hagemeyer, Wyandotte Chemicals Corp.; F. Kaulakis, Consolidated Water Power & Paper Co.; and C. G. Whelpton, The Champion Paper & Fibre Co.

sensitivity had to be established. This was done by the use of a "paired comparison" technique.

During the work it was found that the surface profile test correlated best with print quality, and this test is now used for production control work.

The success of the work meant that very small improvements could be recognized and the results are aptly illustrated by the difference in printability of the art paper beforeand after the full investigation. This work involved assesssment of over 50 changes to the materials and processes concerned, each of which was by itself undetectable in commercial printing trials.

"Coating of Paper in Germany," by M. Judt, Feldmühle Papier und Zellestoffwerke Aktiengesellschaft, Hillegossen, Germany. This was the first public disclosure of details of coating machinery and techniques in the Feldmühle Paper and Pulp Mills Corp., Germany.

In a short historical survey data on machine speeds and machine widths, predrying temperatures, and daily tonnages at the coating mills of Heidenau, Saxony, and Hillegossen, Westphalia, were given, showing the development of off-the-machine coating in the past 30 years.

Raw stock properties and their influence on coater performance, 120-in. wide, were quoted.

After presenting comparative data on coated papers made in the United States and in Germany some differences in quality and approach that have developed were discussed.

On-the-machine and off-the-machine coated qualities were compared and the future of these techniques and their products in Germany was considered.

"Starch Requirements for Paper Coating," by A. Harsveldt, Nationale Zetmellindustrie N.V., Veendam, The Netherlands. One of the most important features of a coating color is water retention. This phenomenon is related to the degree of dispersion of the starch in question and the structure of the starch molecule.

Figures were prepared showing the relationship with degree of dispersion, the method of starch modification, and more especially the influence of groups introduced in the starch molecule by oxidation, etherification, and esterification.

The importance of water retention in transfer coating and its influence on the coating pattern were discussed.

The dynamical yield value is another factor, which can be correlated with the splitting of the coating film between the applicator rolls and the paper. The influence of ionic groups

Harold M. Annis, TAPPI president, presenting TAPPI Certificate of Appreciation to Lloyd H. Silvernail, The Dow Chemical Co., (co-editor, TAPPI Monograph No. 22)

like carboxylic groups which give a high yield value to the coating color was demonstrated in rheological diagrams.

Nonionic groups like hydroxyethyl groups confer a low yield value and are preferred for reducing coating pattern.

The effectiveness of starch as a pigment binder or its adhesive strength is brought into relation with the degree of dispersion and the nature of the groups in the starch molecule.

Carboxylic, carbonyl, and aldehyde groups do not favor adhesive strength. Hydroxyethyl groups are however very effective here.

The receptivity and the drying time of printing inks are reflected by the presence of the coating layer on the surface of the body stock, and the percentage of binder present, and correlate directly with water retention. If we fail to maintain coating hold-up we obtain the effect of an impregnated sheet.

Coating hold-up is more difficult in low solids size-press coating than it is in high solids machine coating.

Transversal sections of good size-press coated sheets were shown, in which the coating layer is on the surface. Also transversal sections of bad coated sheets were shown which show too much impregnation of the coating color. Only in the case there are no difficulties with receptivity and drying of printing inks.

"Rheological Properties and Flow Modifiers for Trailing Blade Coating," by J. F. Hern, Nopco Chemical Co., Harrison, N. J. Because the principles of coating with trailing blade equipment differ so vastly from those of the older, more conventional methods, the rheological properties necessary to give a "good" coating color are also quite different using this type of process.

It therefore follows, that additives used to improve the rheological, surface, and printing properties of high solids, trailing blade coatings need to be unique, since their job is to overcome entirely different (although possibly related) problems than those solved by the use of additives in the past.

This paper described the role additives may play in altering and improving rheological properties of high solids, trailing blade coating colors, so that higher coat weights with improved surface and printing properties, can be produced. Evaluations of rheograms of typical colors prepared using a Hercules high sheer viscometer and coated papers produced on laboratory and Pilot Plant trailing blade equipment were described and discussed.

"Cationic Latex with Controllable Penetration and Set-off Properties," by E. J. Heiser, A. S. Reder, and R. W. Morgan, The Dow Chemical Co., Midland, Mich. Research into latexes for the paper industry has developed a cationic latex with uniquely different properties. This latex has the ability to chemically set instantaneously into an immobile structure upon exposure to an alkali such as ammonia gas. The dry latex film hax excellent water resistance. Pigmented coating containing this latex show a high degree of picking resistance, calendered gloss, varnish holdout, and exceptional wet rub resistance.

This paper discussed latex behavior and formulating techniques. It is considered as a binder for pigmented coating where reactivitiy to alkali indicates a means of controlling penetration into the coating raw stock, set off of wet coating on idler rolls, etc. Pilot plant coater run to investigate the of setoff properties was described and data were presented on coated paper properties.

Panel Symposium

The third technical session was held Tuesday morning, May 9, and took the form of a panel discussion concerning "Adhesives for Coating." L. A. Gilbertson, Marathon Corp., Menasha, Wis., was chairman and R. T. Trelfa, Perkins-Goodwin Co., New York, N. Y., moderator. The panelists and the subjects of ththeir 10-min. presentations were as follows:

Panelists:

F. H. Frost, S. D. Warren Co., Cumberland Mills, Me., "Enamel Papers."
F. Kaulakis, Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis., "Publication Papers."
R. H. Mosher, Kimberly-Clark Corp., Neenah, Wis., "Specialty Papers."
J. T. Loomer, Continental Can Co., New York, N. Y. "Board."
W. P. Taylor, The Champion Paper & Fibre Co., Hamilton, Ohio, "General Comments on Adhesive Developments."

Plant Tours

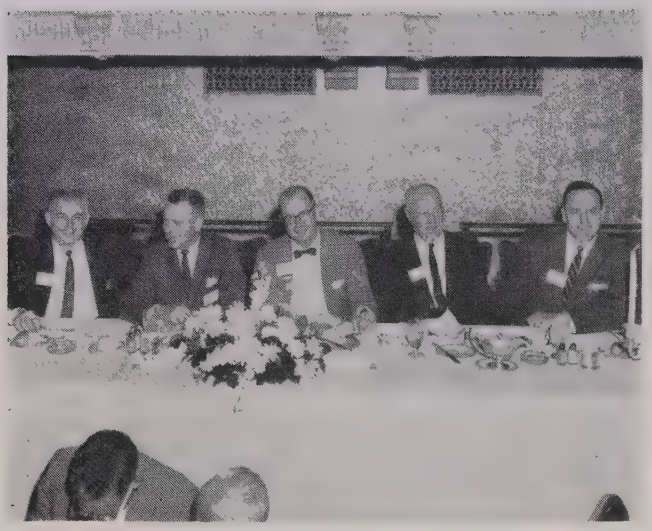
Approximately 300 registrants availed themselves of the opportunity to see one of the following plants which had, through the efforts of C. E. Mikel, Local Arrangements chairman, and R. S. Buckley, Plant Tours chairman, invited coating conference delegates to visit with them:

National Aniline Division, Allied Chemical & Dye Corp., Buffalo, N. Y.
J. W. Clement Co., Lord Street Plant, Buffalo, N. Y.
International Paper Co., Tonawanda Mill, North Tonawanda, N. Y.
Lockport Felt Co., Newfane, N. Y.

Fourth Session

J. D. Wethern, Riegel Paper Co., Acme, N. C., served as

Third Session—L. A. Gilbertson, Marathon Corp.; R. T. Trelfa, Perkins-Goodwin Co.; F. H. Frost, S. D. Warren Co.; F. Kaulakis, Consolidated Water Power & Paper Co.; R. H. Mosher, Kimberly-Clark Corp.; J. T. Loomer, Continental Can Co.; and W. P. Taylor, The Champion Paper & Fibre Co.



Maurice Burnston, TAPPI; C. E. Mikel, Corn Products Co.; C. G. Whelpton, The Champion Paper & Fibre Co.; R. G. Macdonald, TAPPI; and R. W. Hagemeyer, Wyandotte Chemicals Corp.

H. B. Hulse, The Upson Co.; A. H. Nadleman, Consultant, Kalamazoo, Mich.; R. T. Trelfa, Perkins-Goodwin Co.; A. G. Sharp, Senior Vice-President, Kimberly-Clark Corp., and R. W. Martinek, Kimberly-Clark Corp.

chairman for the fourth technical session held Wednesday morning, May 10. An abstract of the single paper presented at this session is given below.

"The Evolution of Coating Preparation in a Bleached Board Mill," by R. W. Bondurant and K. E. Bradway, Union Bag-Camp Paper Corp., Franklin, Va. Solid bleached sulfate board has been coated at Franklin since 1955. The coating preparation system installed initially was a semicontinuous system consisting of a pug mill for clay makedown and blending with adhesives, and a ribbon cooker for adhesives cooking. This system was capable of producing 5000 gal. of coating per day at 55% solids. In 1958 the installation of an air knife coater on a 200-ton-per-day board machine necessitated increasing coating production. A new system was designed to improve flexibility, eliminate foam and cleanliness problems, and improve blending of the clay slip with adhesives. This consisted of a continuous system for clay makedown with air unloading of bulk clay from hopper cars, makedown with the pug mill, and slurry storage at 71% solids. Slurry clay and adhesives were blended in a turbine mixer by pumping through the mixer vessel. This system was capable of producing 12,000 gal. of coating per day at 50% solids. An addition of a Cowles Dissolver was made in late 1960 to increase production rates to 24,000 gal. per day, improve dispersion, and facilitate handling of auxiliary pigments. The capabilities of each of these system is discussed.

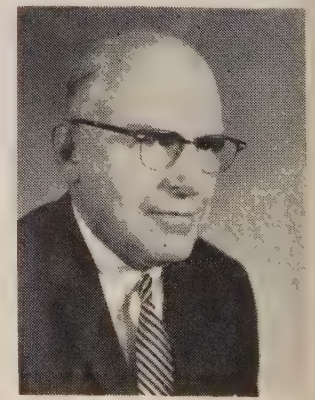
Fourth Session—J. D. Wethern, Riegel Paper Co., and K. E. Bradway, Union Bag-Camp Paper Corp.

Coating Committee Meeting

The Annual Coating Committee meeting was held at 10 a.m., Wednesday, May 10, under the chairmanship of C. G. Landes, North Carolina State College, Raleigh, N. C. This annual session was, as usual, well attended and many items incident to the continuing work of this group were effectively discussed both from the floor and by various member of the Coating Committee Council.

Annual Luncheon

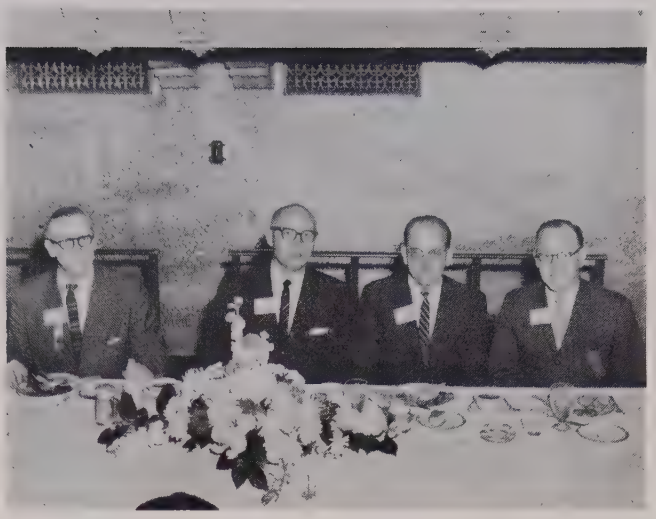
More than 600 conferees gathered together at noon on Wednesday for an informal reception followed by the annual luncheon. R. W. Martinek, general conference chairman, was toastmaster and introduced the head table guests and members of the conference committee. R. T. Trelfa, Coating & Graphic Arts Division chairman, introduced TAPPI President Harold M. Annis who welcomed the conferees on behalf of the National TAPPI. President Annis noted that there were 26 overseas members present, representing seven foreign countries, and described their attendance as being a compliment to the Coating Conference.



A. G. Sharp, Senior Vice-President, Kimberly-Clark, Neenah, Wis.

Describing the assignment as one of great personal satisfaction, President Annis presented TAPPI Certificates of Appreciation, recommended by the Coating Committee

Harold M. Annis, TAPPI President, Oxford Paper Co.; J. E. Wilber, St. Regis Paper Co.; H. O. Ware, Beveridge Paper Co.; C. G. Landes, North Carolina State College



A. J. Winchester, TAPPI; F. Kaulakis, Consolidated Water Power & Paper Co.; W. E. Welliver, Minerals & Chemicals Phillip Corp.; and A. S. Landers, TAPPI

and the TAPPI Awards Committee, to Lloyd Silvernail, Dow Chemical Co., Midland, Mich., and Walter Bain, Central Soya Co., Inc., in recognition of the effort which they had expended in a co-authoring TAPPI Monograph No. 22, "Synthetic and Protein Adhesives for Paper Coating."

C. G. Landes, Coating Committee chairman, introduced the guest speaker, A. G. Sharp, senior vice-president, Kimberly-Clark Corp., Neenah, Wis. Mr. Sharp addressed the luncheon group on the subject "Opportunities Unlimited." The full text of Mr. Sharp's talk will appear in a future issue of *Tappi*.

Fifth Session

The final technical session of the Twelfth TAPPI Coating Conference was held Wednesday afternoon, following the Annual Luncheon. H. H. Lavery, International Paper Co., Corinth, N. Y., was chairman of this session. Abstracts of the three papers presented appear below.

"The Preparation of High Solid Coatings," by H. K. Salzburg, L. E. Georgevits, and W. C. Marino, The Borden Chemical Co., Bainbridge, N. Y. A comparison of the Cowles Dissolver and Baker-Perkins mixer for preparing casein coatings at 50%, 60% solids was discussed. Methods of controlling viscosity and obtaining water resistance in high solid pigmented coatings wee described. These include a study of: (1) the use of dicyandiamide, (2) the effect of pH on viscosity, (3) the use of enzymes, and (4) the use of latex.

With dicyandiamide large quantities are required, 20%, 30% on the casein in order to be effective. It does not impair resistance or adhesive strength.

Low voscosity may be otained working at pH 5.8 or 11.0. At the low pH, offset inks do not dry well but good water resistance is obtained. At the high pH, viscosity stability is a problem and it is difficult to obtain good water resistance.

By using small amounts of enzyme a considerable reduction in viscosity may be obtained at only a slight loss in adhesive strength and water resistance.

By using latex, viscosity may be reduced, and water resistance and flexibility are improved but cost is increased.

Various caseins modified to obtain low viscosity were also described.

"The Use of Polyvinyl Alcohol as a Color Coating Ad-

Twelfth Coating Conference Annual Luncheon

Harold M. Annis, TAPPI president, presenting Certificate of Appreciation to W. M. Bain, Central Soya Co., Inc., (co-editor TAPPI Monograph No. 22)

hesive," by G. P. Colgan, and J. J. Latimer, Air Reduction Chemical & Carbide Co., Bound Brook, N. J. Polyvinyl alcohol has for many years been known to be an excellent binder for paper coatings. Studies of its use in this application have, however, been few in number, and little specific information concerning the properties of polyvinyl alcohol-bound paper coatings has been published.

This paper presented the results of studies carried out to characterize the properties of polyvinyl alcohol coating colors and coated paper.

The colors were found to exhibit rheological properties typical, depending on solids, of Newtonian or shear thinning fluids, and solids viscosity relationships similar to other commercial binders. The adhesive strength was found to be approximately three times that of casein or soy protein and four times that of starch. The optical properties of coatings in general were found to be largely a function of total adhesive content, and, in view of their low binder requirements, polyvinyl alcohol coatings displayed greater ease of calenderability and measurably higher brightness and opacity.

The properties of grease resistance and water resistance were also discussed.

Fifth Session—H. H. Lavery, International Paper Co.; H. K. Salzburg, the Borden Chemical Co.; G. P. Colgan; Air Reduction Chemical & Carbide Co.; and A. D. Jordan, Jr., Rohm & Haas Co.

"A New Multipurpose Resin Emulsion for Paper Coating." by A. D. Jordan, Sr., Rohm & Haas Co., Philadephia, Pa. The properties and typical applications of Rhoplex R-9, an acrylic-modified vinylidene chloride emulsion polymer, are described. Roplex R-9 forms coatings with an excellent degree of resistance to water, solvents, abrasion, and the passage of water vapor. Certain fundamental properties of Rhoplex R-9 such as the shear modulus/temperature relationship of its films are discussed and comparison is made with other thermoplastic polymers.

Thirteenth TAPPI Coating Conference

Anyone wishing to offer a paper for the Thirteenth Coating Conference which will be held May 14–16, 1962, at the Netherland-Hitlon Hotel, Cincinnati, Ohio, should make arrangements with W. E. Welliver of Minerals & Chemicals Philipp Corp., 1404 Potato Point Road, Appleton, Wis.

General chairman of the conference is C. G. Whelpton, The Champion Paper & Fibre Co., Hamilton, Ohio.

Suggestions regarding the program and arrangements for the conference will be welcomed by any member of the committee.

Third EVOP Course

In response to widespread interest in the two TAPPI-ASQC short courses in Evolutionary Operation held earlier this year, headquarters staff is planning a third 2-day course to be held Sept. 15 and 16, 1961 at the Schine Inn, Chicopee, Mass.

As before, the course will be given by Dr. J. Stuart Hunter, member of the Statistical Staff, University of Wisconsin and Truman L. Koehler, head, Statistical Analysis Section, American Cyanamid Co., Bound Brook, N. J.

Evolutionary Operation (EVOP) is a method of operating a process in such a way as to produce on-specification product while simultaneously generating statistical information on how to improve the process (reduce costs, upgrade product quality, increase capacity).

The fee for the course is $100. This includes tuition, supplies, work and note books, two lunches and coffee breaks.

Reservations will be accepted in the order received and must be accompanied by a check for $100. For further information, please contact Miss A. Scott, TAPPI, 360 Lexington Ave., New York 17, N. Y. Hotel reservations should be addressed directly to TAPPI-ASQC EVOP Course, Schine Inn, Chicopee, Mass. Air schedules and other travel information will be sent to each registrant.

Subcommittee for Surface Strength of Paper

H. A. Samuelson, Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis., was appointed chairman of the Subcommittee for Surface Strength of Paper of the Graphic Arts Committee of the Coating and Graphic Arts Division of the Technical Association of the Pulp & Paper Industry in Chicago on April 19, 1961. Other appointments to the subcommittee were A. C. Hamilton, Oxford Paper Co., Rumford, Me., M. Lovensheimer, Mead Corp., Chillicothe, Ohio, R. L. Hagerman, Dow Chemical Co., Midland, Mich.

It was also decided at this meeting to conduct a round-robin series of tests on a suggested method for determining surface strength of paper to be published in the near future. This method is the result of work done at the National Printing Ink Research Institute at Lehigh University, Bethlehem, Pa.

The ground work for the round-robin study will be ready soon. TAPPI members interested in participating in these tests may contact the subcommittee chairman.

TAPPI NOTES

Tappi—Its Editorial Policy and Publication

Although the publication policy for *Tappi* is given in detail in the TAPPI Yearbook, a reminder of its more important provisions, as well as a short explanation of some of the mechanics of the production of the magazine may be of value to *Tappi* readers and future contributors

The copy for *Tappi* comes from several sources, but the bulk is the record of the national conferences of the Association. Manuscripts of papers presented at these conferences are submitted by the author to the program chairman or committee, or to members of the TAPPI technical staff who, in turn, transmit them to the editorial offices of the Association. To keep the other members of the headquarters' staff informed, the editor circulates the manuscripts to them, and the individuals primarily concerned with the subject matter treated in the manuscript may recommend what action should be taken in respect to the paper. Such action would include, for example, obtaining the release of a manuscript reporting the results of a project financed wholly or in part by the Association, transmitting the manuscript to a committee before its publication, or indicating that a paper is a part of series which should be published simultaneously to preserve continuity.

The majority of articles published in *Tappi* comprise those papers received as independent contributions, papers presented at national conferences and local sections, and TAPPI project grant papers. Independent contributions are papers submitted free of any TAPPI sponsorship; they reach us from all parts of the world. Papers read at national conferences or local sections are published in *Tappi* after they have been presented at the meetings. TAPPI project grant papers report the results of research financed wholly or partly by the Association. Papers from all these sources may be submitted for publication in the Technical Section of *Tappi*, but publication in this section is subject to approval by the Editorial Board who review the papers and determine whether:

1. It presents the results of original work on a subject of interest to the pulp and paper industry.
2. It describes a process or equipment that is novel in its concept or application.
3. It presents a critical review of a field of pulp and paper, accompanied by pertinent references.

Because of the scope of TAPPI's activities, papers are sometimes submitted to authorities whose specialty is not represented on the Editorial Board. In any case it is on the advice of specialists that the editorial staff decides in which section a paper is to be published.

The publication of papers resulting from work financed by TAPPI project grants must be approved by the chairman of the Projects Appropriations Committee, the division chairman, and the chairman of the sponsoring committee. Authors of such papers must give, on their manuscripts, the number of the project grant as well as the name of the committee sponsoring the work. This manuscript identification is necessary since the sponsoring committee expects to review the subject matter to ascertain whether the proposed objectives of the project have been attained.

If a paper does not meet Technical Section requirements, it may nevertheless contain material of current interest, and it is therefore published in the Association Section of the magazine. A paper may be rejected if the subject matter falls outside the field covered by *Tappi*, or if its contents are already sufficiently well documented in the literature. It must be emphasized that not all papers presented at a National or Sectional meeting will be accepted for publication in *Tappi*—a paper should be and is published only if it presents something of value.

One of the responsibilities of the editiorial staff is to ensure that all quantitative results reported in a paper are expressed in units of measurement approved by the Association. TAPPI is a world-wide technical organization and its committees are constantly developing and standardizing testing procedures. By following these procedures and reporting the results in the units specified by the Standards, work reported from one laboratory may be duplicated in any other laboratory.

It is recognized that some work is done using methods under development and therefore not yet qualified to be TAPPI Standards, or is done using methods not covered by the Standards. In such cases, the Association insists that either a literature reference or a description of the method be given. Since English units are not universal, *Tappi* editorial preference is for all data to be expressed in metric units, and TAPPI Standard units if available. An author of a paper to be submitted for publication in *Tappi* should never forget that he is writing for a world-wide audience and hence he should express himself and present his data in terms which may be understood by all potential readers.

Every magazine has to contend with printing costs, and *Tappi* is no exception. Such costs restrict the size of the book (number of pages) to be printed. Since the Association has two obligations to its members—publishing technical data and documenting Association activities—one editorial function is the scheduling of papers and other copy. However desirable it may be, it is not always possible to publish the proceedings of a conference in a single issue. The sections devoted to Association activities usually contain information that is of current interest, and such information must be published promptly, otherwise its value is diminished.

The rest of the magazine is taken up by advertising, technical section and current interest papers. Because of space limitations, the publication of papers presented at conferences is spaced over a period of several

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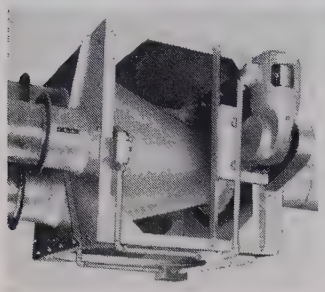

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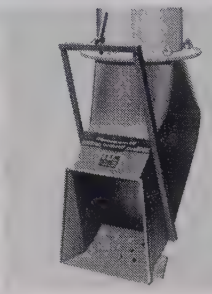

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months, in some cases up to one year. Although this period is generally shortened, authors should be aware that the full year is a possibility.

Another point is the time required to process and print a paper, or release. From the time of makeup to the date of mailing, about a month is required for setting up page, proofing, printing, collating, binding, and mailing. Since time is required for editing and correcting Association notices and communications, another three weeks are necessary. Therefore, all notices of conferences and dates of local section and committee meetings must be in the hands of the editorial offices seven weeks before the date of issue. For instance, releases received before July 25, will appear in the September issue, after the 25th, in the October issue. Technical Section papers are edited and scheduled at least three months prior to the date of publication.

Finally, to reiterate a point made previously, a paper in *Tappi* has a world-wide audience. Its quality has been judged by an authority on the subject matter it presents. Therefore, it behooves the author to know his facts, to present them logically and clearly, with data expressed in TAPPI Standard units, and to give informative illustrations. Insistence is placed on machine-lettered graphs, since hand-lettering varies and detracts from the appearance of the published work. Every member of TAPPI or a reader of *Tappi* is a critic, a specialist, or would-be specialist in his own interests. An author should always be aware of this and strive to present his contributions in such form as to enhance his reputation as well as that of the Association magazine, *Tappi*.

R. T. Bingham, *Editor*

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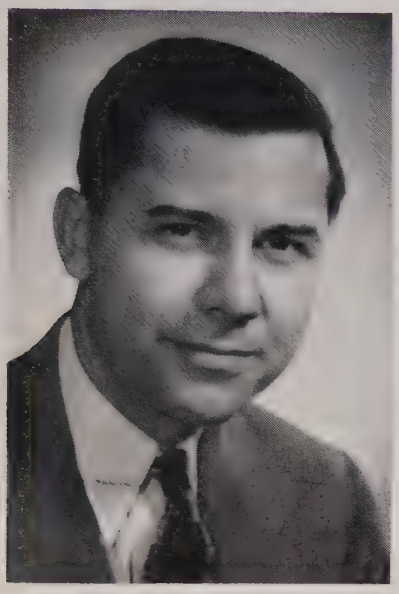

Paul W. Bartholmew

PAUL W. BARTHOLOMEW, a member of the Executive Committee of the Association, is technical director of the Minnesota and Ontario Paper Co., International Falls, Minn.

Born in Kokomo, Ind. in 1909, he received his primary education in Kokomo and University Place (now a part of Lincoln), Neb. In 1930 he received the degree of B.S.Ch.E. from Purdue University, Lafayette, Ind. While in college he was a member of the Theta Tau fraternity and on the Purdue fencing team, winning his major letter in that sport.

Upon graduation he joined Hercules Powder Co. at their experiment station in Kenvil, N. J., and did analytical work on explosives (dynamite, nitroglycerin) and Naval Stores. When the new experimental station in Wilmington, Del., was completed, in 1931, he moved to that laboratory and continued his work on the development of pilot plant and semiplant operations on specialized Naval Stores Products. From Wilmington he returned to Kenvil to assist in the operation of a Naval Stores pilot plant. Shortly after Hercules acquired the Paper Makers Chemical Corp., in 1932, he was transferred to Kalamazoo, Mich., to conduct research and development on dry rosin size. In addition, he served as engineer on the construction of a new chemical laboratory in Kalamazoo, and also as special activities engineer at the company plant in Lockport, N. Y. From 1934 to 1945 he was technical service engineer for the Paper Makers Chemical Division, conducting service work for paper and pulp mills in the Central States.

In 1945 he joined the Hawthorne Paper Co. in Kalamazoo, as technical director. For the next four years he was engaged in development sales, engineering, and paper machine operations. In 1949 he moved to Minneapolis as assistant sales manager in the Paper Division of the Minnesota and Ontario Paper Co. Since 1951 he has been technical director of the company, and resides in International Falls. His responsibilities now extend to the activities of both the Paper and Insulite Divisions.

Paul Bartholomew became a member of TAPPI in 1935. He has served as committee chairman, secretary, treasurer, vice-chairman, and chairman of the Kalamazoo Valley Local Section from 1944 to 1949. He was chairman of the First TAPPI Coating Conference, which was held in Grand Rapids, Mich., in the spring of 1949. In 1955 he was program chairman of the Testing Division Conference in Springfield, Mass., and in 1956, general chairman of the Division. In 1959 he succeeded to the responsibilities of immediate past chairman of the Division.

Besides his membership in TAPPI he is also a member of the American Institute of Chemical Engineers, American Chemical Society, American Society of Quality Control, and PIMA. In Kalamazoo, in 1947, he was a member of the original committee which was instrumental in establishing the course in Pulp and Paper Technology at Western Michigan University.

Mr. Bartholomew has always taken an active interest in community affairs. When he lived in Kalamazoo (1933–49) he was director of the Junior Chamber of Commerce, engaged in PTA work, was a member of the subcommittee of the City Planning Commission, on several boards of the First Methodist Church, a YMCA instructor in fencing, and president of a Methodist men's club. He was also president of the Purdue Alumni Club. In International Falls he is a member of the board of directors and secretary-elect of the local Rotary Club. He was also active in the Keep Minnesota Green (KMG) radio network, for which work he received a public service award from KMG in 1958. He is chairman of the Koochching County Republican Committee, past secretary and president of the Polar Investment Club, and a member of the Masonic Lodge and Shrine Club.

Mr. and Mrs. Bartholomew, the former Virginia Wiley of Kalamazoo, are members of Hennepin Avenue Methodist Church in Minneapolis, as well as being active in church work in International Falls. Mr. Bartholomew is an amateur radio operator and is a member of the Amateur Radio Relay League and Quarter Century Wireless Association. He also enjoys trout fishing, lake fishing, boating, hunting, gardening, carpentry, and reading.

The Bartholomews have one daughter, Judy. She is a Junior at the University of Minnesota, having spent her first two years in college at Mount Holyoke.

PERSONAL MENTION

New TAPPI Members

Edward C. Allison, Partner, Cross & Bevan, Arlesey, Bedfordshire, England, a 1939 graduate of Sunderland Technical College.

David, W. Appel, Professor of Fluid Mechanics, University of Kansas, Lawrence, Kan., a 1947 graduate of Lehigh University, with a Ph.D degree in 1953 from University of Iowa.

Jesse L. Bain, Jr., Project Engineer, East Texas Pulp & Paper Co., Silsbee, Tex., a 1954 graduate of University of Texas.

Roland Baur, Consulting Engineer, A. R. Giannetti Administracao Comercio e Industria S.A., Minas Gerais, Brazil, a 1952 graduate of Oskar v. Miller Institute—Munich.

John E. Bigelow, Manager, Advanced Development Laboratory, General Electric Co., Milwaukee, Wis., a 1944 graduate of Worcester Polytechnic Institute.

Donald S. Blair, Jr., Sales Representative, Monsanto Chemical Co., St. Louis, Mo., a 1951 graduate of Yale University.

William C. Bliesner, Graduate Stuent, The Institute of Paper Chemistry, Appleton, Wis., a 1957 graduate of University of Idaho.

Edgar R. Blount, Development Manager, Celanese Mexicana, S.A., Zacapu, Mich., Mexico, a 1930 graduate of Georgia Institute of Technology.

Ottavialberto Borla, Technical Director, Aeromeccanica Italiana Borla, Torino, Italy.

Harvey J. Brown, Applications Engineer, Steam Generator Div., Clayton Manufacturing Co., El Monte, Calif., a 1949 graduate of University of Pittsburgh.

Robert L. Bruce, Industrial Salesman and Contractor, George L. Simonds Co., Jacksonville, Fla., a 1950 graduate of Kings Point Academy.

John E. Campbell, Manager, Product Development, Polaroid Corp., Cambridge, Mass., a 1954 graduate of Rensselaer Polytechnic Institute, with a Ph.D. degree.

Frank A. Cechner, Supervisor, Special Product Development, Signode Steel Strapping Co., Chicago, Ill., a 1949 graduate of University of Illinois.

William R. Chadwick, Printing Ink Sales, Interchemical Corp., Cleveland, Ohio, a 1957 graduate of Lawrence College.

Arne O. Christensen, Mechanical Engineer, A/S Eureka mek. Verksted, Oslo, Norway.

David C. Clemens, Junior Engineer, Horkey-Moore Associates, Torrance, Calif., a 1959 graduate of Pomona College.

C. Hall Colton, Manager of Industrial Engineering, Continental Can Co., New York, N. Y., a 1935 graduate of Dartmouth College.

Jairo Cupertino, Mill Manager, Duratex S.A. Industrial E Comercio, Jundaiai, Brazil, a 1948 graduate of Escola Politecnica de São Paulo.

Clifford W. Dorman, Manager, Standard Product Sales, The Falk Corp., Milwaukee, Wis., a 1942 graduate of University of Wisconsin.

Cyril L. Ducharme, Sales, General Mills, Inc., Minneapolis, Minn., a 1954 graduate of University of Minnesota.

Helen N. Enlow, Librarian, Ohio Agricultural Experiment Station, Wooster, Ohio.

Lawrence Engle, Sales Engineer, J. O. Ross Engineering, Div. of Midland-Ross Corp., New York, N. Y., a 1954 graduate of Purdue University.

Michael D. Fahey, Section Leader, Pioneer Pulping, Olympic Research Div., Rayonier, Inc., Shelton, Wash., a 1950 graduate of Whitman College with a Ph.D. degree in 1957 from Oregon State College.

Thomas P. Fitzpatrick, Sales Manager, Borden Chemical Co., New York, N. Y., a 1935 graduate of Villanova University.

Mario Fontoura, Superintendent, Pulp & Paper Mfg., Inds. Klabin do Para de Celulose S.A., São Paulo, Brazil, a 1953 graduate of Instituto Superior Tecnico de Lisboa.

Walter T. Gey, Chief Engineer, J. M. Voith G.m.b.H., Heidenheim/Brenz, Germany.

Ronald T. Gielczyk, Process Engineer, Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis., a 1959 graduate of West Michigan University.

Arne E. Gomsi, Staff Scientist, The Mead Corp., Chillicothe, Ohio, a 1949 graduate of University of Minnesota.

Peter J. Gouldstone, Head of Projects Section, Albert E. Reed & Co., Ltd., London, England, a 1946 graduate of London University.

Karl Hiilia, Technical Manager, Sulphate Pulp Mill, Enso-Gutzeit Oy, Kotka, Finland, a 1930 graduate of Finland Institute of Technology.

F. Carl Hirdler, Jr., Technical Supervisor, Pulp & Paper Industry, Turco Products, Inc., Wilmington, Calif., a 1936 graduate of University of Oklahoma.

Douglas N. Horner, Assistant Electrical Superintendent, Bowaters Southern Paper Corp., Calhoun, Tenn., a 1949 graduate of Georgia Institute of Technology.

Dexter P. Huntington, Supervisor Silicone Product Development, Union Carbide Co., Tonawanda, N. Y., a 1951 graduate of University of Chicago.

Ian J. Ingram, Mill Manager, Portals (John Allen & Sons), Ltd., Ivybridge, Devon, England.

John H. Johnson, President, Johnson & Johnson Engineers-Architects, Inc., Chicago, Ill. Attended Illinois Institute of Technology.

Robert G. Johnson, Assistant Paper Mill Superintendent, Eastern Fine Paper and Pulp Div., Standard Packaging Corp., Lincoln, Me., a 1951 graduate of University of Maine.

John J. Jordan, General Superintendent, Fabricas de Papel Tuxtepec S.A. de C.V., Tuxtepec, Oax., Mexico.

Takashi Kataoka, Chief of Engineering Dept., Mitsubishi Denki Co., Ltd., Kobe-shi, Japan, a 1938 graduate of Kyoto University.

M. A. K. Khalil, Director, Pakistan Forest Research Laboratory, Sholashahar, Chittagong, East Pakistan.

William J. Kiernan, Supervisor, Paper, Textiles and Color Control, Bell Telephone Laboratories, Inc., Murray Hill, N. J., a 1934 graduate of New York University.

Toshiki Kusuyama, Chief, Research Labs., Nihon Kagaku Kogyo K.K., Wakayamashi, Japan, a 1953 graduate of Osaka Prefectural University.

Pentti O. Larvio, Assistant Technical Manager, Enso-Gutzeit Oy, Kotka, Finland, a 1952 graduate of Institute of Technology.

Ralph C. Lees, Sales Representative, Koppers Co., Inc., Plastics Div., Chicago, Ill., a 1959 graduate of Williams College.

Friedrich A. Lehmann, Chief Chemist, Axel Springer & Son, Hamburg, Germany, a 1924 graduate of Friedrich-Wilhelm University, Berlin, with a Ph.D. Degree.

Paul K. Liliestrom, Mill Manager, OY Wilh. Schauman AB, Jakobstad, Finland, a 1934 graduate of Technical University of Helsingfors.

Hector D. Mackenzie, Chief Chemist, Usutu Pulp Co., Ltd., Mhlambanyati, Swaziland, South Africa, a 1949 graduate of University of Birmingham with a Ph.D. degree in 1952.

Henry P. Markant, Research Engineer, Babcock & Wilcox Co., Alliance, Ohio, a 1948 graduate of Lafayette College.

Roman G. Martin, Jr., Associate Development Chemist, A. E. Staley Mfg. Co., Decatur, Ill., a 1960 graduate of St. Ambrose College.

Wm. M. McNiel, Manager of Sales, Building Products, Bauer Bros. Co., Springfield, Ohio, a 1926 graduate of Iowa State University.

H. Walter Moeller, Chemist, National Starch & Chemical Corp., Plainfield, N. J., a 1957 graduate of N. Y. State College of Forestry.

Klaus Moller, Paper Engineer & Colorist, Farbwerke Hoechst AG, Frankfurt, Germany, a 1952 graduate of Polytechnikum, Munich.

Harry E. Montanye, Assistant Plant Manager, Interchemical Corp., Elizabeth, N. J., a 1953 graduate of Drexel Institute of Technology.

Edward R. Muhring Technical Director, Balatum, Ltd., Huizen, The Netherlands, a 1947 graduate of Technical University, Delft.

Rene Noordtzij, Head, Chemical Dept., Sandoz, Inc., New York, N. Y., graduate of University of Neuchatel, Switzerland, with a Ph.D. degree in Science.

Christopher S. Norton, Engineer and Office Manager, Walmsley (Bury) Group, Ltd., London, England.

Henrik Paersch, Technical Manager, OY Kyro AB, Kyroskoski, Finland, a 1945 graduate of University College of Technology, Helsinki,

David F. Pagel, Chemical Engineer, Fort Howard Paper Co., Green Bay, Wis., a 1955 graduate of Michigan College of Mining & Technology.

Eberhard Peiler, Production Manager, Renker-Belipa KG, Germany, a 1955 graduate of Technische Universitat, Berlin.

James F. Pflum, Assistant Vice-President, Technical Dept., Pennsylvania Industrial Chemical Corp., Clairton, Pa., a 1939 graduate of University of Dayton.

Donald G. Pryor, Consolidated Water Power and Paper Co., Wisconsin Rapids, Wis., a 1957 graduate of Western Michigan University.

Charles S. Pugh, Jr., Project Engineer, Owens-Illinois Glass Co., Big Island, Va., a 1956 graduate of Virginia Polytechnic Institute.

Erkki A. Pursiainen, Head, Dept. of Pulp & Paper Machinery, A. Ahlstrom OY, Warkaus, Finland, a 1949 graduate of Finland Institute of Technology.

Roger L. Richey, Plant Engineer, Owens-Illinois Glass Co., Big Island, Va., a 1950 graduate of University of Illinois.

Rudi E. Richter, Technical Service and Development, Dow Chemical Co. of Canada, Ltd., Sarnia, Ont., Canada, a 1957 graduate of McGill University.

Fred P. Ritchie, Plant Manager, Paper Mill, Container Corp. of America, Santa Clara, Calif., a 1945 graduate of U. S. Naval Academy.

Richard Rue, Industry Manager, Pittsburgh Chemical Co., Protective Coating Div., Summit, Ill., a 1940 graduate of Beloit College.

Daniel R. Sachs, Technical Assistant to the General Superintendent of Paper Production, Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis., a 1959 graduate of University of Wisconsin.

Robert O. Scott, Sales, Beloit Iron Works, Beloit, Wis.

Richard S. Seidel, Development & Service Manager, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., a 1948 graduate of Notre Dame College.

Ryoichi Senju, Professor, University of Kyushu, Fukuoka, Japan, a 1937 graduate of University of Kyushu, with a Dr. of Agriculture degree.

Daniel P. Shannon, Technical Representative, Union

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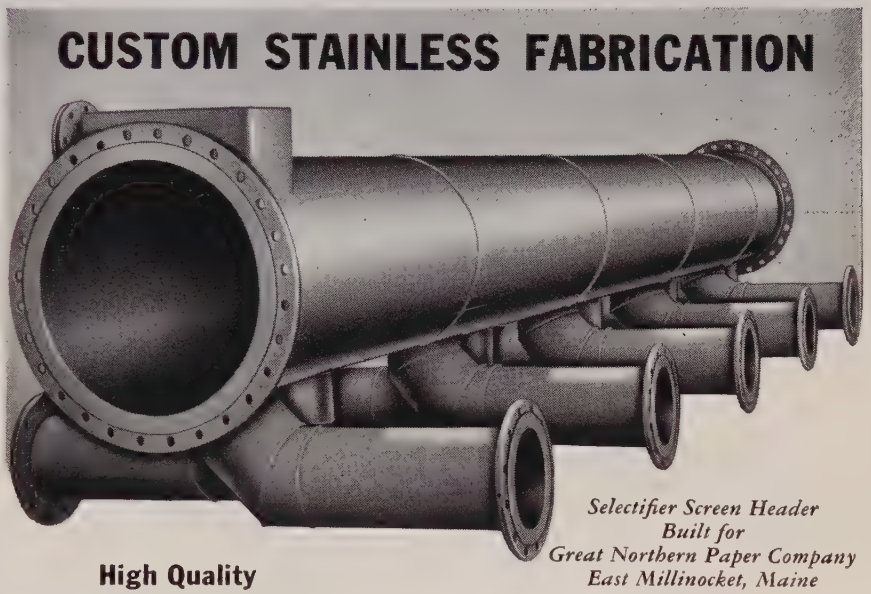

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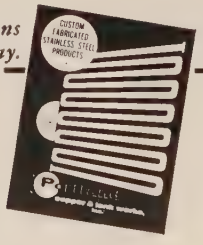

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F. A. Sharr, State Librarian, Library Board of Western Australia, Perth, Western Australia.

Anne Stone, Librarian, Federal Institute of Industrial Research (Federal Ministry of Commerce and Industry), Ikeja Airport, Nigeria.

Warren Stubblebine, Sales Manager, Stowe-Woodward, Inc., Newton Upper Falls, Mass., a 1938 graduate of Pennsylvania State University with a Ph.D. degree in 1942.

Jan Suleng, Laboratory Engineer, Meieriindustriens Emballsjeinstitutt A.S., Vollebekk, Norway, a 1948 graduate of Stockholms Tekniska Institut.

S. Graeme Turnbull, Jr., Assistant Director, Technical Laboratory, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., a 1938 graduate of University of Virginia.

Carl D. Vessele, Engineer, International Nickel Co., Inc., New York, N. Y., a 1954 graduate of Muskegon College.

Maarten Veth, Development Engineer, Koninklijke Papierfabrieken Van Gelder Zonen NV, Renkum, The Netherlands, a 1957 graduate of Technical University, Delft.

Francisco R. Villanueva, Chief Chemist, C. A. Venezolana de Pulpa y Papel, Moron, Venezuela, a 1958 graduate of University of Maine.

Stuart A. Warshaw, Vice-President, Sales, Berkshire Color & Chemical Corp., Springfield, Mass., a 1952 graduate of Colby College, Rhode Island School of Design.

George K. Whitehead, Paper Mill Manager, Wiggins Teape Paper Mills, Ltd., Chorley, Lancs., England.

George M. Williams, Chief Industrial Engineer, Consolidated Paper Co., Monroe, Mich., a 1933 graduate of Auburn University.

Robert G. Wilson, Research Engineer, Huyck Felt Co., Rensselaer, N. Y., a 1954 graduate of Massachusetts Institute of Technology.

Charles R. Witschonke, Manager, Paper Chemicals Research, American Cyanamid Co., Stamford, Conn., a 1937 graduate of Kalamazoo College with a Ph.D. degree in 1941 from Brown University.

Appointments

Ronald Argonin, Technical Service Engineer for Champion Paper & Fibre Co., Hamilton, Ohio, will be in the Army Reserve for the next six months. He will return to Champion.

Austin F. Anthus, formerly of Champion Paper & Fibre Co., is now in the research division of St. Marys Kraft Corp., St. Marys, Ga.

Donald Appleton, Vice-President of Oxford Paper Co., retired on May 1.

Stuart Bergman is now Director of Technical Services for the Gilman Paper Co., New York, N. Y.

Harold A. Bergstrom is now Director of Research and Development for the Fibre Drum Div. of Continental Can Co., Chicago, Ill.

M. P. Bhargava, formerly of Rohtas Industires, Ltd., is now with Star Paper Mills, Ltd., Saharanpur, U. P., India.

Howard M. Blandin, formerly Chief Chemist of Consolidated Paper Co., has retired and now lives at 927 So. 19th St., Quincy, Ill.

David Bookchester is now Vice-President for Adhesives Sales of Morningstar-Paisley, Inc., New York, N. Y.

Thomas W. Cadden, of West Virginia Pulp & Paper Co., has been transferred from N. Charleston, S. C., to Hinde & Dauch Division, St. Louis, Mo., as a Product Development Engineer.

Carleton J. Campbell, formerly of Wabash Fibre Box Co., is now Vice-President for Mill Sales of Weston Paper Mfg., Co., Terre Haute, Ind.

Henry D. Chanzy, formerly of The French Army, is now an Engineer with Papeteries di Vizelle, Vizelle (Isere), France.

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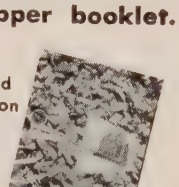

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Paul B. Corning is now a Staff Engineer with Day & Zimmerman, Inc., Philadelphia, Pa.

Antonio Corona S., formerly with Papelera Chabacano S/A., is now Plant Manager of Celfinex S/A, Mexico, D.F.

Charles N. Egan, formerly of Little Rapids Pulp Co., is now President of Shawano Paper Mills, Green Bay, Wis.

Bruce Ellen, formerly of Southern Paperboard Co., is now Production Manager of Southern Land & Timber Co., Atlanta, Ga.

Richard W. Flores is now Technical Superintendent of the Upper Mills of Riegel Paper Corp., Riegelsville, N. J.

Durward B. Geffken is now Manager of the Paper Mill Department of Sealright-Oswego Falls Corp., Fulton, N. Y.

C. Ives Gehring is now Manager of Paperboard Procurement for Sealright-Oswego Falls Corp., Fulton, N. Y.

Louis G. Good, formerly of Panellit Service Corp., is now President of Systems Service Corp., Charlotte, N. C.

Robert Gordon formerly of Albany Felt Co., is now a Sales Representative for Union Starch & Refining Co., Inc., Columbus, Ind.

Ansel L. Hargraves is now Vice-President in Charge of Research and Development of St. Joe Paper Co., Port St. Joe, Fla.

Jerry G. Hedin, formerly of Appleton Woolen Mills, is now a Consultant in Oberlin, Ohio.

Howard L. Heise is now Vice-President in Charge of Research for the Gummed Products Division of St. Regis Paper Co., Troy, Ohio.

James L. Horton is now Manager of the molded packaging plant of Diamond National Corp., Red Bluff, Calif.

Jaro Holy is now Manager of Chemical Sales for Consolidated Water Power & Paper Co., Appleton, Wis.

Donald A. Hunter, of Diamond National Corp., has been transferred from Red Bluff, Calif., to New York, N. Y., as Assistant Director of Manufacturing.

Robert F. Huntley is now President of Cowles Chemical Co., Cleveland, Ohio.

Sjarif Ismail, formerly of N. V. Fabrik Kertas, is now Chemical Engineer for Bank Pembangunan Indonesia, Djakarta, Indonesia.

Thomas M. Keville, Jr., formerly of Robert Gair Div. of Continental Can Co., is now a Paper Technologist at the Quartermaster Research and Engineering Command, Natick, Mass.

Gregory Klebanoff, Jr., formerly of Pfaudler Permutit, Inc., is now with E. D. Jones Corp., Pittsfield, Mass.

David J. Kraske, of Oxford Paper Co., has been transferred from Rumford, Me., to Lawrence, Mass., as Coating Superintendent.

Harry F. Kurz, Assistant Sales Manager of Link Belt Co., has been transferred from Philadelphia, Pa., to Chicago, Ill.

Chester G. Landes is now Professor of Pulp and Paper Technology at North Carolina State College, Raleigh, N. C.

Robert E. Lehman, formerly with Georgia Kaolin Co., is now in the Sales Department of the Pigment Division of the Glidden Co., Balitmore, Md.

A. M. Leth is now Technical Assistant to the General Director of Celulosa de Chihuahua, S/A., Chihuahua, Mexico.

James A. Lewis, of the Lee Paper Co., has been transferred from Vicksburg, Mich., to Ripon, Calif., as Technical Director of Simpson-Lee Paper Co.

Hubert M. Lyle, formerly of St. Francisville Paper Co., is now Coating Supervisor of Bowaters Carolina Corp., Catawba, S. C.

Charles E. Miller is now Manager of Industrial Sales and Engineering Operation for the General Electric Co., Schnectady, N. Y.

Henry W. Moser is now Vice-President for Engineering of Samuel M. Langston Co., Camden, N. J.

Charles P. Mosher, formerly of American Sisalkraft Corp.,

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is now a Project Engineer for Great Northern Paper Co., Millinocket, Me.

Elbert H. Neese, Jr. is now President of Beloit Eastern Corp., Downington, Pa.

Ashley D. Nevers, of Pennsalt Chemicals Corp., has been transferred from Wyandotte, Mich., to King of Prussia, Pa., as Supervisor of Industrial Chemical Applications at the technical service laboratories.

Albert Oetken is now Assistant Manager of the Hudson River Mill of International Paper Co., Palmer, N. Y.

Michael Pavol, Jr. is now a technical service representative for Minerals & Chemicals Philipp Corp., Menlo Park, N. J.

Harry S. Pedley, of Champion Paper & Fibre Co. has been transferred from Pasadena, Tex., to Hamilton, Ohio, as Director of Paper Manufacture in the Production and Process Improvement Department.

Ruprecht W. Pirzer, formerly of West Virginia Pulp & Paper Co., is now Technical Director of Hoffman & Englemann A/G., Neustadt Weinstrase, Germany.

Vincent J. Plansky, of the Dow Chemical Co., has been transferred from Midland, Mich., to Boston, Mass., as a Salesman.

Simon Posen is now Vice-President in Charge of Special Assignments for the Gilman Paper Co. New York, N. Y.

Claude A. Raby is now Divisional Manager of Sales for J. M. Huber Corp., New York, N. Y.

Calvin J. Reis, formerly of the New York & Pennsylvania Co., Inc., is now a Paper Technologist for American Cyanamid Co., Bound Brook, N. J.

Merrill D. Robison, of Weyerhaeuser Co., has been transferred from Cosmopolis, Wash., to Tacoma, Wash., as Assistant to the Manager of Manufacturing in the Pulp and Paperboard Division.

John M. Rudolf, formerly of Parsons & Whittemore de Mexico, is now with the Paper Converting Machine Co., Green Bay, Wis.

Harry Schuschny, formerly of Parsons & Whittemore SRL, is now an Engineer for Ledesma S.A.A.I., Buenos Aires, Argentina.

Ronald R. Schutts, of St. Regis Paper Co., has been transferred from Carthage, N. Y., to Tacoma, Wash., as a Technical Service Engineer.

Clarence W. Scott, of the International Paper Co., has been transferred from Springhill, La., to Panama City, Fla., as Assistant Manager of the By-products Division.

George E. Sewall, formerly of the Glidden Co., is now a Chemical Engineer at the Portsmouth Naval Shipyard, Portsmouth, N. H.

H. Scott Smith, formerly of Fibreboard Products, Inc., is now Assistant Pulp Mill Superintendent for Georgia Pacific Corp., Toledo, Ore.

Charles R. Stones, formerly of Price Bros. Co., Ltd., is now President and General Manager of Alsto Paper Machinery, Lachine, Que.

Luigi Terziotti, formerly Engineer with Cartiere Burgo, is now with Black-Clawson International, Ltd., London, England.

Mahesh C. Varshney, formerly a Student at the New York State College of Forestry, is now a Project Engineer with Consolidated Water Power & Paper Co., Wisconsin Rapids Wis.

John A. Vazdikis, formerly of the West Virginia Pulp & Paper Co., is now a Project Engineer with the Reigel Paper Co., Milford, N. J.

Wallace E. Voeks, formerly a Research Assistant at The Institute of Paper Chemistry, is now a Research Chemist for the Rochester Paper Co., Rochester, Mich.

V. J. Westbrook, formerly of the St. Regis Paper Co., is now Resident Manager of Waldorf-Hoerner Co., Missoula, Mont.

Isao Yamada, formerly of Toyama Rayon Pulp Mills, is now President of Kinsei Paper Mfg. Co., Ltd., Kochi City, Japan.

* * *

J. J. Devlin has succeeded *P. J. Gianacakes* as the official representative of Cities Service Research & Development Co., New York, N. Y., in the Technical Association.

Robert S. Davis has succeeded *K. E. Fryfogle* as the official representative of Brandon Sales Co., Greenville, S. C., in TAPPI.

Robert Grieff has succeeded *J. F. Orr* as the official representative of Curtiss-Wright Corp., Princeton, N. J., in the Association.

M. A. Buchta, Manager of the Industrial Division, has succeeded *D. O. Eschbach* as the official representative of Gilbert Associates, Inc., Reading, Pa., in TAPPI.

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INDUSTRY NOTES

Paper Manufacturers and Converters

Brown Co.

Selection of a Black-Clawson tissue machine for installation in Brown Co.'s Cascade mill at Gorham, N. H., has been announced by Joseph Hill Torras, executive vice-president of the northern New England pulp and paper firm.

The new machine, from Black-Clawson's Paper Machine Div. at Watertown, N. Y., is scheduled to go in operation in May, 1962.

Installation of the tissue machine will be by Brown Co. construction personnel with Black-Clawson supervision. Engineering services will be supplied by the Rust Engineering Co. of Pittsburgh, Pa. Preliminary relocation of other mill equipment to create necessary floor space for the machine, its stock preparation equipment and finishing facilities, is already underway.

The new 101-in. machine will be equipped with a 12-ft. diam. Yankee drier and all-electric sectional drives. Of advanced design, it will include high accuracy speed regulators and will be supplied from its own pulper, refiners, and other stock preparation equipment, to be furnished principally by the Shartle Division of Black-Clawson.

The Black-Clawson machine is designed to produce a complete line of sanitary tissue products of highest possible quality and uniformity without sacrificing machine speed. Brown Co. intends to market cellulose wadding in bleached and unbleached grades as well as a full line of toilet and facial tissues for industrial and institutional uses.

Pulp for the tissue machine will come from Brown Co.'s Burgess sulfite pulp mill, and will consist largely of bleached and unbleached hardwood and softwood sulfite pulp.

Celgar, Ltd.

Celgar, Limited is a subsidiary of Columbia Cellulose Co., Ltd. which has operated a dissolving and specialty sulfite pulp mill at Prince Rupert on the northern British Columbian coast since 1951. Columbia Cellulose, through Chemcell, Ltd., is affiliated with Canadian Chemical Co., Ltd. at Edmonton and with Celanese Corp. of America. These two companies buy much of the Prince Rupert production for the manufacture of textiles, chemicals, and plastics.

The head office of both Columbia Cellulose and Celgar is in the Burrard Building, 1030 West Georgia St., Vancouver, B. C.

In 1952 Celgar purchased sawmilling interests in the Arrow Lakes Region of British Columbia and has since operated a sawmill at Nakusp and one at Castlegar. Following years of exploration and study to determine the quality and quantity of the timber resources in the Arrow Lakes area, Celgar was issued Tree Farm Licence No. 23 by the Provincial Government. This licence gives the company the right to cut timber grown on 860,000 acres of forest land in the Columbia River basin in a series of blocks between Castlegar and Mica Creek. In return the company has undertaken to manage and harvest the forests in conformity with B. C. Forest Service standards.

The site of Celgar's new pulp mill and integrated sawmill is located $2^1/_2$ miles up the Columbia River from Castlegar, a community with a population of about 1900 persons situated on the Columbia River at the foot of the Arrow Lakes. These lakes extend for about 100 miles northward as a wide, slow-running portion of the river. Above the lakes are a further 100 miles of the Columbia River which are suitable for the towing or driving of the log bundles. This system forms the basis of the company's log transportation.

The logging headquarters are situated at Nakusp, on the Upper Arrow Lake. Revelstoke will also be a center for logging operations in the northern block of the Tree Farm Licence area. The City of Revelstoke has a population of about 3500 and with the surrounding area included, 5500. Nakusp has about 1200 people.

The company has invested approximately $50 million in woods, sawmill, and pulp operations. The construction program includes a new sawmill capable of producing 62 million ft. of finished lumber annually as well as chips and hog fuel for the pulp mill.

Forest Utilization

With the construction of the kraft pulp mill, many species of trees which are not saleable as lumber can now be harvested for pulp production.

Species found in the area include western red cedar, western hemlock, Englemann spruce, balsam fir, Douglas-fir, white, ponderosa and lodgepole pine, larch, cottonwood, birch, and aspen. Nearly 40% of the wood from the Tree Farm Licence will be suitable for sawlogs with the balance going into pulpwood.

Woodroom

The supply of logs to the woodroom has three sources: (1) bundled logs from Celgar's woods operation normally towed down the Arrow Lakes in bundles of 10 to 15 cunits of solid wood. These bundles will be sorted in the woods so that no logs over 35 in. diam. will go to the pulp mill; larger sizes will be directed to the sawmill for lumber or broken down into smaller pieces, (2) purchased logs can come in by rail, (3) from truckers.

This wood will all be handled by one 60-ton Colby crane

Celgar's new bleached kraft pulp mill, located on the Columbia River just north of the U. S.-Canadian border, has brought a new era to British Columbia's interior forest operations. As the Province's first pulp mill off tidewater, integrated use of the forest resources for lumber and pulp is possible in this area for the first time. The integrated logging, lumber, and pulp mill operation represents a 50 million dollar investment

The bundle booms are moved from the booming ground to storage areas along the Arrow Lakes. Here rectangular bundle booms of pulp logs are shown in storage just above the mill. Circular bag booms shown contain logs for Celgar's present sawmill operating at Castlegar. The new sawmill also will handle bundles

Chips from the woodroom, shown in the background, travel by conveyor into one of the two chip silos, or directly to the screen room (seen behind the silos), or into open storage. As an added precaution against dirt, chip screening takes place after storage immediately prior to the chips going to the digesters

and bundle grapple and transferred to a breakdown deck in the woodroom. From this point, individual logs have two routes depending on size. Lots up to 24 in. diam. can go to a 30-in. Hansel hydraulic barker and directly to a 112-in. nine-knife horizontal chipper, driven by a 1250 hp. 327 r.p.m. synchronous motor. This chipper when making $^3/_4$ in. chips, has a through-put speed of 194 f.p.m.

The second log line is to a 42-in. Hansel hydraulic barker and directly to a 154-in. six-knife horizontal chipper, driven by a 1500 hp. 277 r.p.m. synchronous motor. With these two similar chippers operating side by side, the advantages of the nine-knife over the six-knife chipper are immediately apparent.

The unscreened chips are carried by a rubber belt to an outside elevated conveyor. This conveyor terminates at the two chip silos. From this point the chips can go to the silos for supplying the digesters or to the outside chip storage.

Chip Handling

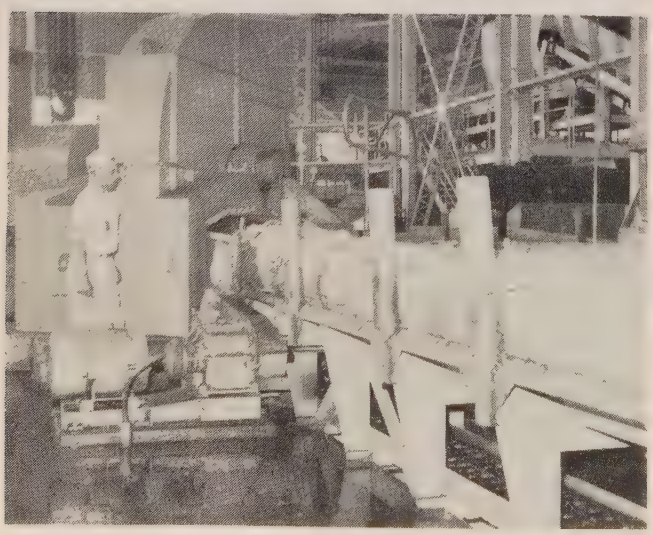
A system of conveyors starting at the chipper, conveys the unscreened chips to the two chip silos or to the pile. The chips to the digesters are first screened through four 6 by 12 ft. three-deck Dillon screens from either the silos or the outside storage. Recovery from the pile is by an end loader to air conveyor feed and thence to a chip elevator feeding the screens. Chips from the silos are withdrawn by pan type feeders conveyed by belt to the chip elevator and thence to the screens.

Rejects from the screens go to a rechipper and are returned for screening.

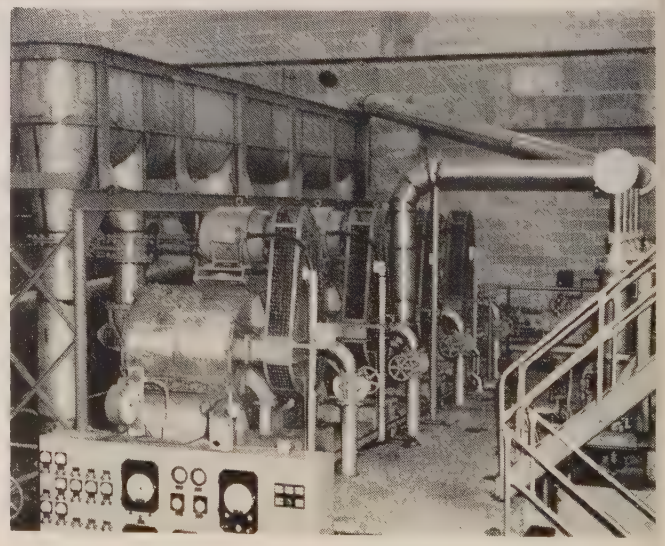
When the sawmill operates, chips from their operation will be delivered to the mill chip pile by air-veyor and reclaimed with the regular mill system.

Refuse System

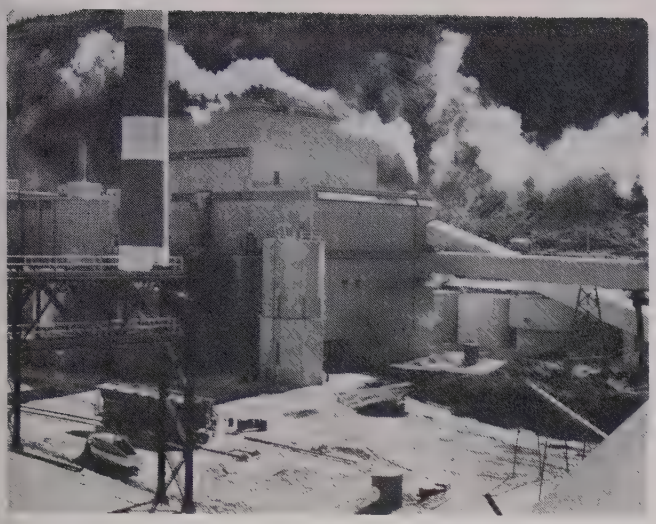
All bark and wood waste from the breakdown decks, log conveyors, barkers, chip screens, and clarifier are conveyed to a 42-in. Montgomery hog. This product goes directly from the hog to a fiber making process bark press and by belt conveyors to the Foster-Wheeler power boiler. This boiler has



In order to utilize 50-ft. logs, Celgar has installed horizontal chippers so that the logs pass by conveyor directly from the barker into the chipper. Two such combinations, one for large logs and one for small logs, have been installed



Primary screening of unbleached kraft is handled by four of the new K-400 series Cowan centrifugal pulp screens manufactured by S. W. Hooper & Co., Ltd., Montreal. Characterized by a long and narrow cylinder design, the screens operate under unusually high consistencies, which require less water per ton of accepted fiber, resulting in substantial operating economies. The elongated cylinder design promotes greater separation with a consequent reduction of secondary screening



Heart of the kraft pulp process, the steam and recovery plant is one of the high lights of the new Celgar mill. Careful design was instrumental in achieving a considerable reduction in floor area without loss of working area. Scheduling of structural work in advance of equipment installation enabled the recovery boiler to be completed in about 13,000 man-hours—about one third of the time required on many equivalent installations

four pneumatic spreader stoker feeds and the excess bark, if any, is returned to an outside storage pile.

Bark from the sawmill operation is pumped to the pulp mill woodroom to a rotary dewatering screen. This bark then joins the woodroom refuse system to the hog and press. Hogged sawmill residue and sawdust are conveyed to the pulp mill by air and go to the boiler along with the woodroom hog fuel.

To minimize river pollution, all effluent from the barkers goes to a 100-ft. diam. EIMCO clarifier. The sludge from this clarifier is returned to the hog fuel system for burning and only the clarified effluent enters the river. The drainage from the floors and any overflow from the sludge screens are added to the bark flow from the sawmill and thence to the hog fuel system.

Pulping Group

This section is comprised of the digesters, brown stock washing, screening, dirt separators, and black liquor oxidation equipment.

Digesters. Two Kamyr continuous units have been installed, each capable of providing 275 tons per day.

Brown Stock Cycle. Chips are conveyed from the chip screens to hoppers feeding directly to the presteaming vessels, then through high pressure feeders to each digester. From the digesters, pulp is blown continuously to a single blow tank of 50 tons capacity. From the blow tank stock is pumped to three Sherbrooke enclosed knotters and to a three-stage brown stock washing system of three 11 ft. 6 in. by 20 ft. Sherbrooke washers. Stock from the third washer goes to the headbox of the four Cowan screens and then to the screened stock chest. From this chest the stock is pumped through the C.I.R. dirt separators to the brown stock decker and thence to unbleached high-density storage.

Bleaching Cycle. The bleach plant is comprised of five stages: chlorination, first caustic, first chlorine dioxide, second caustic, and the final stage of chlorine dioxide.

Stock from the high-density brown stock storage is pumped at controlled consistency and volume to the first bleaching stage, the chlorination tower. In flow sheet sequence the tower is followed by an 11 ft. 6 in. by 20 ft. washer to the first caustic stage tower. From this treating tower, the flow is to another washer and to the first chlorine dioxide tower. This tower is followed by a third washer, and a second caustic tower. From this tower the flow is to a fourth washer and thence to the final stage of chlorine dioxide followed by a fifth washer.

Stock from this last washer goes to three C.I.R. centriscreens with secondary and tertiary stages, followed by the small model C.I.R. primary, secondary, tertiary, and quaternary stages of cycleans. The screened stock passes over an 11 ft. 6 in. by 20 ft. vacuum decker and to a bleached stock high-density storage.

Machine Room

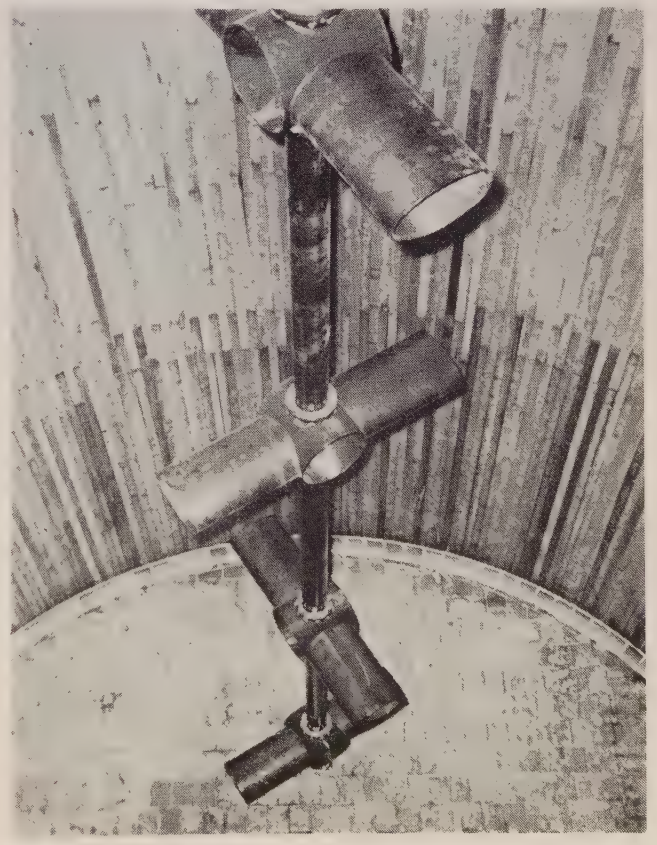
The machine room has no basement, but has a mezzanine floor along a section of the south wall to accommodate the heat recovery fans and an electrical switch room.

The 192-in. fourdrinier-type wet end machine was supplied by John Inglis and consists of a fourdrinier section with stationary flat boxes and a roto-belt section, two suction type presses, two predriers and a plain third press.

The drying machine proper is an airborne type "W" S. F. Flakt drier with 17 passes. There is a sheet transfer section between the third press and the drier.

The cutter and layboy together with the transfer conveyors were supplied by Lamb-Grays Harbor, and two baling presses by Baldwin-Southwark. The bale tying machines were supplied through Don Dugdale of Tennant Development Co., and the stacker and up-ender by Lamb-Grays Harbor.

The power boiler, the recovery boiler, the precipitator, the water treatment plant for the boiler feedwater, the black liquor evaporator, the mill air compressors, and the high pressure water pumps for the hydraulic barkers are housed in a building separate from the other process buildings. A 250-ft. smoke stack handles the waste gases from both boilers.



Three per cent kraft stock is stored in a 34 ft. diam. by 50 ft. high tank and blended by means of a Cowan stock agitator. The three-shaft, four-unit agitator is composed of tubes, each functioning as a high volume, low head pump, instead of conventional blades and paddles. Because agitation can be closely controlled by this method, full and uniform blending, particularly around the walls of the tank, is assured. This installation has a low power consumption of only 225 hp. The agitator was manufactured and supplied by S. W. Hooper & Co., Ltd.

The power boiler has three sources of fuel supply: (1) bark and hogged sawmill waste, (2) natural gas, and (3) bunker C oil. Bark and either gas or oil can be fired simultaneously or separately. The recovery boiler is equipped with oil burners for starting up the unit. Both units have turbine driven I.D. fans, and the power boiler also has an electric drive that would be used if no steam were available.

The Recausticizing Cycle

The recausticizing building houses the Dorr slaker and pumps as well as the discharge end of the F. L. Smidth lime kiln and has the clarifiers and liquor storage tanks along the south and north sides. An overhead bridge connects the black liquor oxidation and kiln feed building.

Shops and Stores, and Administration Building

These facilities are located on the west end of the pulping group. The administration building projects northward, providing an entrance to the time clocks from the east side and to the main office from the north side. The building has three floors, each provided with entry to the pulping group building.

This arrangement of the repair shops, stores, and administration building, in relation to the major areas in the mill, conserves travel time to a minimum and makes for an extremely efficient working arrangement.

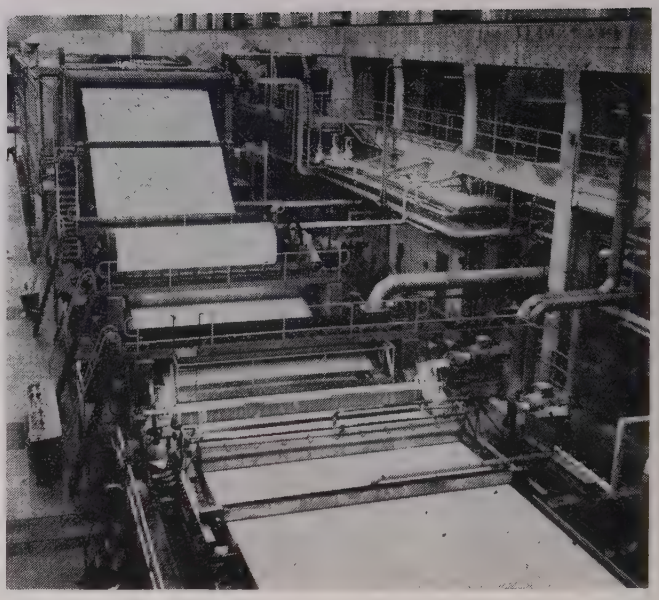
Electrical Installation

The mill is supplied with electrical energy from Consolidated Mining and Smelting Co.'s hydroelectric plants. Two transmission lines at 66,000 v. to two 3-phase, 66,000 to 13,000 v. transformers, each capable of carrying the full mill load and paralleled on the low voltage side. Each transmission line is fed from separate sources of Cominco's system so that a failure of one line should not affect the supply to the pulp mill. These transformers are situated just south of the pulp mill and power is carried on two overhead aluminum circuits to the main mill substation.

The mill system is a radial 13,000 v. distribution system emanating from the main substation which is the terminus of the incoming lines. From this sub, 11 cable circuits supply eleven 2500 kva., three-phase, 13,000/600 v. transformers and two cable circuits to two 3000 kva., 13,000/2300 v. transformers. The radial feeder circuits are fed through circuit breakers with overload and fault protection.

The circuits from the area transformers to the motors are practically all Teck cable with D.S.T.A. and either neoprene or P.V.C. covering. The cable is supported on trays suspended from the building roof beams. A very limited amount of conduit has been used where circuits had to go in the floor slab.

The mill has a single 10-ft. dia., 250-ft. F. L. Smidth lime kiln. Recausticizing building also houses Dorr slaker and pumps as well as the discharge end of the kiln



Celgar has installed a John Inglis fourdrinier section which is 192 in. wide and has a range of speeds from 150 to 750 f.p.m. The Airborne Flakt drier, first of its kind in British Columbia, is an example of the advanced engineering and equipment featured in the project

All motor starters are located in motor control centers housed in rooms located near the load center of the area being supplied.

This design has resulted in an extremely flexible and economical installation. It should result in very low maintenance and high serviceability throughout the life of the mill.

All mill motors are 550 v. with the exception of one 1500 hp. chipper motor, one 1250 hp. chipper motor and five 600 hp. pump motors which are 2300 v. All motors up to and including 30 hp. 1800 r.p.m. are T.E.F.C., the remaining motors wound with random wound coils are classified as floodproof. These motors have the windings impregnated with an epoxy resin and are considered capable of operating under extremely adverse conditions of moisture and in corrosive atmospheres. They have the significant advantage over the T.E.F.C. of a 1.15 service factor resulting in 15% bonus in capacity. The larger motors with form wound coils do not have the epoxy impregnations, but do have an improved coil and slot insulation where milar and dacron synthetics are combined with polyester resins and dipped in an improved hydrocarbon resin for surface protection. This type of winding as compared to conventional class A insulation provides 50% increase in dielectric strength and 700% in physical strength and adds about 100% to the winding life expectancy.

With the exception of the incoming lines, there are no overhead power lines on the pulp mill site.

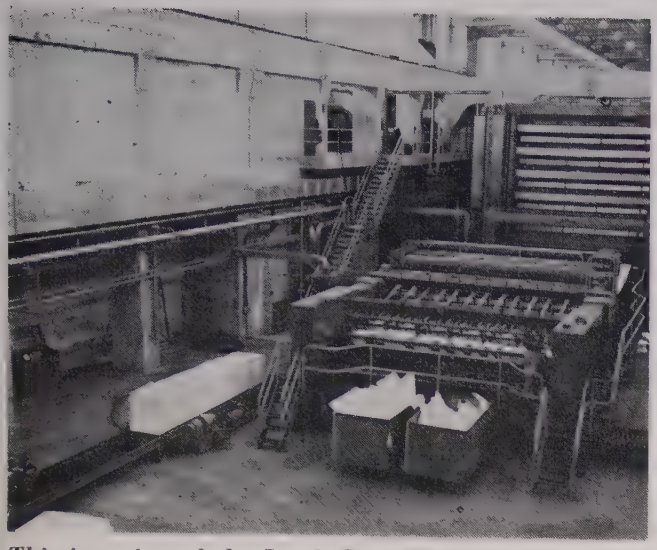
Lighting

Mercury vapor lighting has been installed in all high bay lighting. The initial cost was higher, but the saving in power and maintenance offsets extra cost in a very short time, since the lamp life is roughly 12 times that of standard incandescent bulbs.

Another feature of the lighting is the use of lamps that do not require reflectors. The use of reflectors under pulp mill conditions is at best unsatisfactory. They soon change from reflectors to light absorbers and the general illumination deteriorates yearly and can only be kept near peak efficiency by a continual costly program of washing and cleaning.

Steam Turbines

The plant steam study indicated the average production of



This is a view of the Lamb-Grays Harbor cutter-layboy and the end of the Flakt air-borne drier. Baling process, bale tying machines and bale stacker complete the finishing room

steam from the recovery boiler and the hog fuel boiler (hog fuel from sawmill and woodroom) would economically justify the use of approximately 8000 hp. turbine drives in place of electric motors. These turbines are Westinghouse manufacture and were supplied with reduction gears when required. The exhaust steam all goes to process use.

In the case of the boiler feed pumps, a third pump is equipped with electric motor drive, and this also applies to the fire pumps where one is electric driven.

The I.D. fan for the power boiler has an auxiliary electric motor drive (200 hp.) to be used in starting up the unit with no steam available from the other boiler.

Piping

The material specifications for piping were governed by the following combination of factors: serviceability for the specific use, expected maintenance costs, expected life, product or corrosion resistance, cleanliness, and installed cost. The dominant factor was corrosion resistance and product cleanliness.

In the use of aluminum piping, some cast aluminum hangers have failed in service. Rather than attempt a pick and choose replacement service, it was decided to replace all hangers 8 in. and up with steel, using polyester wrap between the hangers and the aluminum pipe. This is not a condemnation of aluminum hangers, but rather the type used in this project. The replacement was prompted initially by failures of the hangers on a 24-in. diam. suspended water line. In the use of polyester resin fiberglass reinforced piping in the bleach plant, corrosion resistance was the major factor in its use. This material clearly serves a useful function in bleached kraft mills, and will steadily improve as mill experience is gained.

The several types of stainless have been extensively used. Approximately 90 tons of this material have been used throughout the mill for piping uses alone. Extreme care is required in welding the lighter gages and the protected arc welding apparatus is superior.

Steel is still the major piping material. All high-pressure (600 lb. and over) lines were carefully tested and x-rayed for welding imperfections and very little trouble has resulted. A series of failures resulted on welded 75 p.s.i. steam mains. The trouble was all after a desuperheater installation where treated boiler feed water was used for desuperheating purposes. The failure has resulted from caustic embrittlement due to the water treatment chemicals and has now been corrected.

Piping in bleached kraft mills is a major cost item and justifies very careful engineering attention in both choice of materials and fabrication techniques.

Fresh Water Supply

The mill requirements for 500-ton production have been set at 40,000,000 g.p.d. maximum, the basis being 550-ton peaks at 72,000 gal. per ton.

The several factors to be considered were:

1. The use of the river to float approximately 400,000 cunits of logs per year for pulp and sawmill use, added to the difficulty of a river intake.

2. The Columbia River has a mean annual variation in level of over 35 ft., again contributing to an expensive intake installation.

3. The color of the river water during flood conditions increases. This annual increase above 5 p.p.m. would be a problem when making 90 brightness pulp.

With these factors in mind, consideration was given to wells as a source of water.

A firm of water geologists undertook a study which included the drilling of test wells. This investigation required about 4 months and cost approximately $40,000. The final report with recommendations was received. All evidence was strongly in favor of a system of wells, both from the standpoint of economics and consistent quality.

Bids were then requested and the successful bidders agreed to supply a minimum of 40,000,000 U. S. gal. per day of water that would meet TAPPI Standards for bleached kraft pulp for a contracted sum of money.

Four wells were constructed along the bank of the river with horizontal laterals projecting out under the river. The flow of water was in general higher than anticipated, but the quality has failed to meet the specifications. The total hardness in all cases was too high and all wells under some pumping conditions have had sand contents up to 50 p.p.m. A great deal of work has been done trying to improve the quality, generally without success. It now appears that two of the wells only will be usable. To operate the mill, it was found expedient to install a 30 in. intake, 384 ft. long, from the river to no. 2 well and use this well which had two 8000 gal. pumps installed simply as a pumping chamber.

To date there is no explanation of the difference in quality from the test wells, compared to that from the finished collectors. It appears that by using a mixture of river and well water, the mill requirements can be met.

This somewhat detailed description is given as the experience may be useful to others considering wells as a source of supply, also to point out the pitfalls inherent in water procurement plans, even when extensive test programs have been carried out.

Antipollution Measures

Although no method has yet been developed that makes it feasible for the complete elimination of pulp mill odor, the use of continuous digesters and the installation of the latest in black liquor oxidation techniques help to reduce odor to the minimum.

There are few mills in North America which have built in as many antipollution features as Celgar. No expense has been spared to control pollution and this aspect has been given top priority throughout the design of the mill. Recent operating experience indicates that the mill compares favorably with any on the North American Continent.

Some of these features include: strategic placement of tanks to capture process spills; a 100-ft. diam. clarifier to remove bark and fibrous solids from the effluents; a modern sewage treatment plant for sanitary wastes; highly efficient electrostatic precipitators and scrubbers to recover chemical dusts; and an underwater diffuser system to dilute and mix liquid effluents.

Consolidated Water Power & Paper Co.

Three personnel appointments at the Appleton Division of

Consolidated Water Power & Paper Co. have been announced by H. J. Lausman, division manager.

Jaro Holy has been appointed manager, chemical sales; Dennis Wilch has been named product development chemist for the division; and G. Kent Dickerman has been appointed Project Chemist.

Continental Can Co.

ROBERT GAIR PAPER PRODUCTS GROUP

In order to consolidate the paper mill manufacturing and board sales activities of Continental Can Co. into one operating division, an organizational realignment transfers operations of the company's boxboard plants in Haverhill, Mass., Middletown, Ohio, Natick, Mass., and Tonawanda, N. Y., from the Folding Carton and Drum Division into the newly named Paperboard and Kraft Paper Division. This division was formerly known as the Containerboard and Kraft Paper Division.

STAFF

H. A. Bergstrom, Continental Can Co.

H. A. Bergstrom has been named director of research and development for fiber and steel drums at the General Packaging Research and Development Division in Chicago, it was announced by P. P. Wojtul, vice-president in charge of boxboard, folding carton, and drum operations. Mr. Bergstrom was previously director of research at the fiber drum laboratories in Van Wert, Ohio. These laboratories will now be consolidated in new Chicago facilities where research and development work is also done on other forms of packaging involving use of paper and plastic materials.

Coastal Timber Land & Pulp Corp.

The Coastal Timber Land and Pulp Corp. of Perry, Fla. has announced a major break through in the utilization of hardwoods in the Southern States. In a few parts of the South what might be called "soft" hardwoods have been used in small quantities for the manufacture of both wallboard and semichemical pulp. Heretofore, these woods which have been used are popular, willow, cottonwood, gum, and the like. Nothing, however, has been done on the "hard" hardwoods such as the oaks, hickory, and similar hardwoods. Coastal Timber Land and Pulp Corporation will use these "hard" hardwoods for the manufacture of insulating boards and S-2-S hardboards by the Linzell-Tayler combination process.

They plan to make insulating boards in thicknesses of $^1/_2$, $^3/_4$, and up to $1^1/_2$ in. at densities between 15 and 20 lb. per cu. ft. S-2-S hardboards in thicknesses of $^1/_8$, $^3/_{16}$, $^1/_4$, $^3/_8$, $^1/_2$, $^5/_8$, and $^3/_4$ in. in densities between 35 and 68 lb. per cu. ft.

The refiners will be Modulators from Sweden made by Celleco. The forming machine will be the double cylinder type made by A. Ahlstrom Oy of Finland who will also make the press section, the wet saw, the automatic dry trim saws, and the automatic hardboard trim saws. The Wallboard Dryer Corp. of Elizabeth, N. J., will make the drier while G. Siempelkamp & Co. of Germany will make the hot plate press.

In order to make the thick semihardboards according to The Tayler Corp. patent pending, a Girdler Corp. high frequency unit with a 200 kw. output will be used. The overall engineering work and the responsibility for installing the plant and setting it in operation has been assumed by The Tayler Corp. of Elizabeth, N. J.

Gilman Paper Co.

Howard Gilman, executive vice-president of Gilman Paper Co., manufacturer and converter, announces the promotion of Simon Posen to the office of vice-president in charge of special assignments. Simon Posen joined Gilman in 1949 as director of the New York Technical Department. He has functioned importantly in the company's expanded manufacture of pulp, paper, and converted products, in company-customer relations, and in the development of bleached sulfate board, bleached and unbleached specialty papers, and many by-products.

Stuart Bergman, for the past six years assistant director of the Technical Department, has been promoted to director of Technical Services.

The Gilman Paper Co. operates integrated mills and converting plants at Gilman, Vt., and St. Marys, Ga. New York headquarters are now located in the Time & Life Building, Rockefeller Center.

Great Northern Paper Co.

RESEARCH AND ENGINEERING CENTER

M. C. McDonald, president of Great Northern Paper Co., announced plans for the construction of a new $1,500,000 Engineering and Research Building at the company's Millinocket plant. Construction began in May and the building is expected to be ready for occupancy by March 1, 1962.

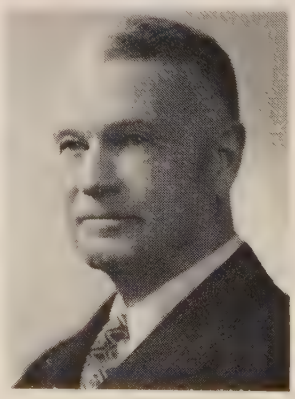
Proposed Engineering & Research Building, Great Northern Paper Co., Millinocket, Me.

The modern new building will provide an area of 40,000 sq. ft. for laboratories, engineering drafting, offices, and a library; plus a 13,000 sq. ft. area for pilot plant, other experimental facilities, and storage space. In form it will consist of a central building for engineering and research, with an administrative wing and a pilot plant wing.

International Paper Co.

The Board of Directors of International Paper Co. at their annual organization meeting, designated John H. Hinman honorary chairman of the Board and also appointed him director of woodlands. He will continue to serve as a member of the Board of Directors.

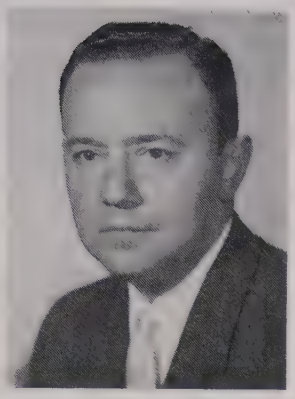
Replacing Mr. Hinman as chairman of the board will be Richard C. Doane, who has served as president of the company since 1954 and as chief executive officer since 1959. Mr.



John H. Hinman, International Paper Co.

Richard C. Doane, International Paper Co.

Lamar M. Fearing, International Paper Co.



Joseph P. Monge, International Paper Co.

Doane will continue to be chief executive officer. Lamar M. Fearing was elected to succeed Mr. Doane as president and Joseph P. Monge was elected vice-president and treasurer.

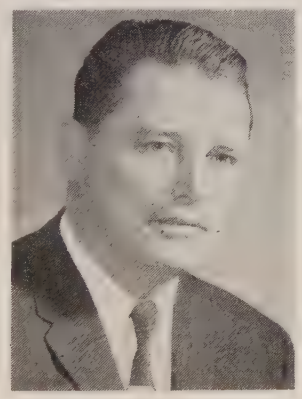
ADVERTISING PROGRAM

International Paper Co.'s national advertising program, "Send Me a Man Who Reads," has been awarded a tie for First Place by the *Saturday Review* in its Ninth Annual Advertising Awards Competition. The campaign shared top honors with The New York Life Insurance Co.'s program on careers for young people.

The awards are made for "distinguished advertising in the public interest." The winners are selected by a special awards committee of 28 outstanding business and professional men, including educators, company presidents, and advertising specialists.

The copy theme of the series that, "men who read more, achieve more," is backed up in each advertisement by research into the reading habits of various groups; i.e., businessmen, doctors, students, farmers, congressmen, teachers, etc. The response to the series has been so intense from all sides that to date requests for more than 850,000 reprints have been honored.

Irving Pulp & Paper Co., Ltd.



Anthony A. Yankowski, Irving Pulp & Paper Co., Ltd.

Anthony A. Yankowski has been named mill manager of Irving Pulp and Paper Co., Ltd., a Canadian associate of Kimberly-Clark Corp.

National Starch & Chemical Corp.

GRANITE BOARD DIVISION

Nonwarping, nonswelling composition board is making rapid advances in the furniture and building industries. With a price advantage over most lumber products and property advantages over economical plywood, the common $^3/_8$ to 1 $^1/_8$-in. board is being used more and more for underlay in new construction, and for base wood in furniture construction, thus replacing layers of plywood. It is also seeing service as decorative paneling, shelving, and woodwork.

Developed out of economic necessity in wartime Germany and the Scandinavian peninsula, the industry did not begin its North American growth until the middle of the last decade. Since then, its surge has been phenomenal. When Granite Board Div. of National Starch and Chemical Corp. was founded in 1954 as the independent Granite Board Co., the

From start to finish at Goffstown. Silo receives chips from rail car or truck, feeds them to driers and mills. Then chips are air classified in Sturtevant air separator (middle of photo) and selected chips are processed: fines are sent to 20-mesh screen (below cyclone collectors at right). Separator, eliminating multiple screening points, is standard 10-ft. unit fabricated by Sturtevant Mill Co., Boston, Mass.

Goffstown, N. H. facility was one of only six composition board plants in the nation. Today, there are close to a hundred plants devoted to the production of this sturdy, decorative building material. Not only do these plants offer a new, exciting product; they serve indirectly the cause of conservation through the greater utilization of timber. At Goffstown, all granite board products are made of thin chips, up to a half inch in size, of white pine shavings.

Processing these chips—converting them to sturdy building products—calls for intricate separation of fines from the chips, careful blending-in of binders, and close-tolerance, weight-controlled pressing of the finished board.

Until 1957, the company performed all particle-size selection steps with a battery of screens. When National Starch bought the company that year, the original firm was considering air separation of the particles to assure better quality control, faster and more efficient operation, and increased capacity with a subsequent housekeeping improvement over the dusty multiscreen process.

Thus it was that a little over 2 years ago, Granite Board installed a 10-ft. centrifugal air selector, a standard unit engineered and fabricated by Sturtevant Mill Co. of Dorchester, Boston, Mass., manufacturers of a complete line of air separation equipment and chemical processing machinery. Since installation of the Sturtevant air separator, production has spurted so that, had the plant continued to handle all classification by screens, the company by now would have had to have at least doubled the number and complexity of the screens, with resultant personnel and process adjustments. With the air separator having replaced the screening system except for four screens at critical process points, Granite Board has been able to handle continuing production increases without the expense of additional equipment or labor.

The Sturtevant unit operates three shifts a day, 13 days out of 14. On the fourteenth day, the entire plant is shut down for maintenance. Officials say that if it were not necessary to clean other processing equipment, the separator conceivably could continue around-the-clock every day, although preventive-maintenance-conscious National Starch officials feel that one-day shutdown for overall maintenance and cleanup at Goffstown is a prime factor in the plant's minimal down time-for-repairs record and its excellent safety record.

Actually, though the separator operates on all three shifts, it does not operate continuously. Change of board thickness or composition, production requirements and other such relative factors play key roles in determining how many hours the unit actually runs. At present, it processes over a hundred tons a day. The biweekly cleanout during regular plant shutdown, and the regular oiling and greasing require no unscheduled down time. The separator is washed down annually.

When Granite Board shifts from the manufacture of one board to another, the air volume and rate of feed to the separator are adjusted accordingly. The required particle sizes also dictate adjustments in rate of feed and airflow, but the adjustments are minimal and simple and plant men claim they take less time than climbing the stairs to make them.

For most Granite Board applications, the separator is adjusted to remove 40-mesh and larger particles, with a predominance of 12- to 20-mesh and a small percentage of 20 to 40. These particles later are combined with a binder for dry pressing. To explain better how this is done, it is best to trace the shavings from arrival to finished product.

Fibers are pneumatically conveyed to one of three bulk siloes which feed them to one or both of two driers. The drying operation is necessary, because the chips contain up to 50% moisture, and Granite Board requires chips with less than 8% moisture to maintain high-quality composition board. After drying, the particles are either diverted to a hammermill if they are extremely large, or passed directly through a screen which feeds into further process, sending oversize to the hammermill. The mill is also followed by a screen, which recycles oversize. From these two screens, the chips, with a percentage of fines, are pneumatically conveyed to a main silo which feeds the focal Sturtevant air separator via variable screw conveyor and bucket elevator.

Upon entering the separator for classification, the particles are carried to the center of an interior revolving distribution plate; the vanes of which shoot them off its outer edge in an even, horizontal, circular spray where the air separator draws air through the falling, revolving particles. One fan sucks the finer particles upward while a lower fan whirls the upcoming material and forces coarse sizes away from the opening. Simple adjustments of feed rate and airflow control centrifugal force and air currents, one counteracting and overbalancing the other so that almost any desired fineness may be selected.

At Goffstown, the separator feeds the oversize, desired fines to a screen for a further size check, after which the passed particles are pneumatically conveyed to an automatic weight surge hopper which screwfeeds a blender where chemical additives are intimately intermixed with the wood chips. The chips leave the blending process with the adhesive physically indistinguishable from the fiber. They then are ready to be conveyed to forming machines, which precipitate the mat forms, weigh check the composition board and send the mats, 15 at a time, to a press where the board is pressed under predetermined pressure and temperature into an oversize 4 by 8 board. The pressed board then is trimmed, stored for a day or more and sanded and cut to size for shipment to customer. The trimmings are returned to a hammermill and recycled. The sandings are also salvaged for by-product use.

While the separator feeds the oversize to the fabrication plant, it feeds the rejected fines, with a percentage of oversize, through two cyclone collectors to a vibrating screen. The 20-mesh screen passes most of this material, but oversize which may have escaped the separation process is recycled for a second pass with new material. The dust and sandings from board manufacture are also conveyed to this screen for recovery of oversize and intermixture of fines with the small particles rejected by the separator. These screened fines are sold to an industry which requires minus 20-mesh particles for filler material.

Thus Granite Board takes an initial by-product, makes a further product and by-product from it. Everything that arrives at Goffstown goes out as salable product.

Thanks to the air separator, not only does a salable by-product result from the process, but the primary product—composition board—is upgraded in quality, since it is free of crumbly dust which could deleteriously affect performance. Thanks to air separation too, a dust problem which was inherent in multiple screening was licked, with resultant morale and maintenance improvement.

The surge in industry, the constant developments underway at National Starch and Chemical Co.'s Plainfield, N. J., laboratories, and the diverse sizes of materials received at Goffstown; all could have collaborated to make problematical the manufacture of the company's product.

Owens-Illinois Glass Co.

Research and Testing Laboratory

A new research and testing laboratory dedicated to the improvement of paper products—from tree to corrugated and solid fiber shipping boxes and multiwall bags to carry countless products to market—has been opened in Toledo, Ohio, by the Forest Products Group of Owens-Illinois Glass Co. The new facility, located adjacent to O-I's famous Technical Center, ranks as one of the best equipped in the paper industry.

The laboratory combines all the research and development activities of the paper products, mill, and multiwall bag divisions. The activities of the new unit are broken into five major laboratories:quality development, box and bag testing, design engineering, quality audit, and research and development. These are manned by chemists; mechanical, chemical, civil, paper, and packaging engineers; physicists; mathematicians; graphic artists, and statisticians.

Oxford Paper Co.

Philip L. Hovey, Oxford Paper Co.

The election of Philip L. Hovey to the position of vice-president, operations, was announced today by William H. Chisholm, president, Oxford Paper Co. The promotion of Mr. Hovey to this new position is coincident with the May 1st retirement of Donald Appleton, vice-president, Oxford Paper Co.

David J. Kraske has been promoted to the position of coating superintendent of the Lawrence, Mass., Division, effective May 15, 1961. He joined the Oxford research organization in 1959 as assistant group leader of the Coating Group, and in 1960 he was promoted to research scientist.

Printing Manual

Oxford Paper Co.'s new illustrated 40-page manual "Paper and Web Offset Printing," compiled from a broad range of industry sources, offers for the first time a comprehensive study of what is known today of papers for this process and the problems arising from their use. It will be of interest to those printers now using web offset, printers contemplating its use, as well as many others in the graphic arts industry with a general interest in the process.

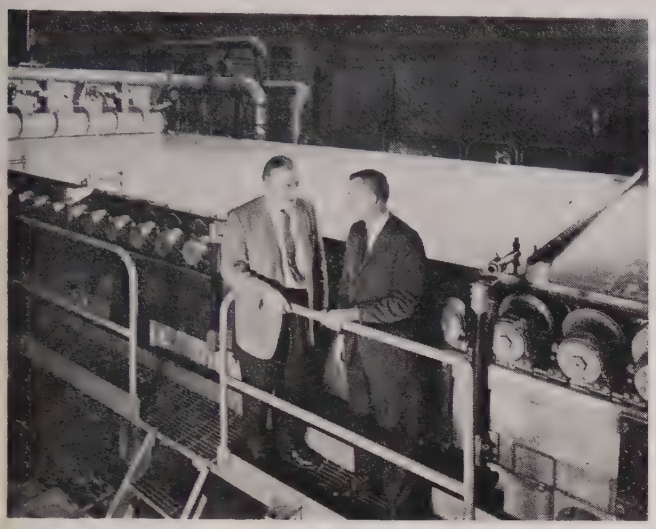
The 11 sections deal with such topics as "The Web Offset Process" and its advantages, as well as disadvantages. A section is devoted to the types of paper currently in use, as well as an additional section on "The Ultimate Web Offset Paper." Other sections deal with such subjects as "Paper Problems on the Press" and "Ink Problems Related to Paper."

Of particular interest to many currently using or contemplating the process is the section "The Phenomenon of Blistering" which discusses not only the causes of blistering but also suggests several remedies.

Contact your local Oxford merchant for a copy or, if he is temporarily out of stock, write to Oxford's Advertising Department at 230 Park Ave., New York 17, N. Y.

Potlatch Forests, Inc.

Potlatch Forests, Inc., and International Business Machines Corp. announced that they have joined forces for an early September effort to apply computer controls to one of man's oldest and most temperamental manufacturing processes—the art of papermaking. Company spokesmen stated they would unite a specially tailored IBM 1710 process control unit—first of its kind in the paper industry—with one of two machines at the main Potlatch plant in Lewiston. Each 500-ft. machine is currently producing 250 tons of specialized paperboard per day.

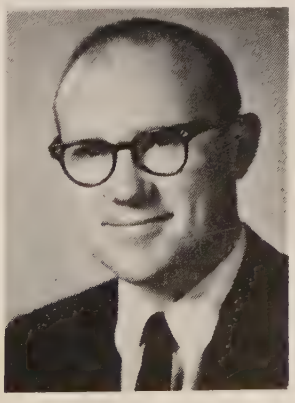


One of the critical areas to be monitored by the Potlatch Forests, Inc., process control system to be installed at their Lewiston, Idaho, paper mill later this year is the headbox and Fourdrinier portion of the paper machine. Application of the IBM 1710 to this process is discussed on the machine itself by V. V. Vallandigham, Potlatch vice-president for pulp, paper, and converting, at left, and production manager Donald T. Keller

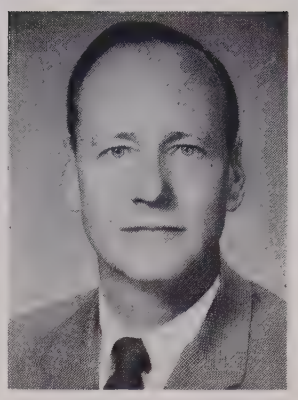
St. Joe Paper Co.

Three operating executives of the St. Joe Paper Co. have been elected to the company's Board of Directors, according to an announcement by Edward Ball, president. They are: A. L. Hargraves, chief chemist at the company mill in Port St. Joe, Fla., who also was elected vice-president in charge of technical services and developments for the entire company; Donald P. McNelly, general manager of the company's Rochester, N. Y., plant, and L. W. Trapp, Jr., general manager of the Houston plant.

A. L. Hargraves, St. Joe Paper Co.



D. P. McNelly, St. Joe Paper Co.



L. W. Trapp, Jr., St. Joe Paper Co.

Scott Paper Co.

INDUSTRIAL FELLOWSHIP

Scott Paper Co.'s research division has announced that its Industrial Fellowship is open to applicants.

The fellowship, created in 1959 by the company's research group, offers postgraduate work at The Institute of Paper Chemistry, Appleton, Wis. The objective of this fellowship program is to increase the basic knowledge of fibrous material.

Candidates for the fellowship must have a thorough foundation in physical chemistry, including a well-rounded background in bonding forces between atoms and molecules, structure of polymeric materials, surface chemistry and physics, and materials.

Although Scott seeks a candidate who has earned a Ph.D., the appointment will not be limited to those holding doctorates, provided other qualifications are favorable. Previous experience with the pulp and paper industry might be helpful. However, such experience is not a requirement.

The successful applicant will become a member of Scott's research division, but he will be supervised by staff members at The Institute. Scott and The Institute will coordinate closely on the applicant's research activities.

Letters of application or inquiries should be directed to Kenneth W. Britt, Associate Director of Research, Scott Paper Co., Philadelphia 13, Pa.

Sealright-Oswego Falls Corp.

Sealright-Oswego Falls Corp. is observing the 75th anniversary of its founding at home plant and offices in Fulton, N. Y. At the speakers dais at a recent luncheon held to commemorate the diamond anniversary are, from left: F. C. Ash, chairman of the board, Sealright-Oswego Falls Corp.;

Guests at the diamond anniversary dinner of the Sealright-Oswego Falls Corp. at Fulton, N. Y.

Keith S. McHugh, commissioner of the Department of Commerce, State of New York; R. Reid McNamara, vice-president, Sealright-Oswego Falls Corp. and president of Sealright Co., Inc.; H. C. Estabrook, president, and C. M. Tooke, executive vice-president, Sealright-Oswego Falls Corp. The paper packaging firm was founded in 1886 on the banks of the history-laden Oswego River at Fulton as the Oswego Falls Pulp and Paper Co. Today, Sealright has plants in Kansas City, Kans., Los Angeles, Calif., Peterborough, Ont., and maintains offices in principal cities across the country.

STAFF

Henry C. Estabrook, president of Sealright-Oswego Falls Corp., announces promotion of C. Ives Gehring to manager of paperboard procurement and of Durwood Geffken to

C. Ives Gehring, Sealright-Oswego Falls Corp.

Durwood Geffkin, Sealright-Oswego Falls Corp.

succeed Mr. Gehring as manager of the paper mill department of the company. Both will be responsible directly to C. M. Tooke, executive vice-president of the company.

In his new position Mr. Gehring will consult with supplier paper mills on "runs" of paperboard supplied by "outside" mills for several types of Sealright products.

Tennessee River Pulp & Paper Co.

Completion of a $41,000,000 kraft liner board mill at Counce, Tenn., was announced jointly by Tennessee River Pulp and Paper Co. of New York City, and Packaging Corp. of America, of Evanston, Ill.

The opening of the Counce mill is the realization of one of the inherent advantages of the three-company merger which formed Packaging Corp. of America 21 months ago. Two of the three predecessor companies of Packaging Corp., Central Fibre Products Co., and the Ohio Boxboard Co., participated in the formation of Tennessee River Pulp and Paper Co.

The Counce mill, designed under the guidance of Gunnar Nicholson, president of Tennessee River Pulp and Paper Co., is one of the world's most modern and efficient paperboard producing facilities. It will produce 170,000 tons of kraft liner board annually and deliver the entire output to the owner companies. St. Regis Paper Co. and Bell Fibre Products Corp. own the remaining 48% interest.

In addition to mill construction, the investment of $41 million includes capitalization, timberlands and building of a 16-mile railroad.

With its 52% ownership in Tennessee River Pulp and Paper Co., Packaging Corp. has a proportionate ownership interest in 160,000 acres of both softwoods and hardwoods in Mississippi, Alabama, and Tennessee. These timberlands were acquired to provide a reserve source of pulpwood for the new mill, although the primary source of pulpwood will be provided by independent timberland owners and logging contractors. Forest management programs for the Counce mill procurement area have been under way for some time.

Weston Paper and Manufacturing Co.

GENERAL HISTORY

In 1893 Edward B. Weston founded The Weston Paper Co. with production facilities located at Greenfield, Ind. Late the same year he incorporated The Weston Paper and Manufacturing Co. at Dayton, Ohio, primarily to sell the mill production at Greenfield. In 1899 The Weston Paper Co. moved to Terre Haute, Ind., and the name was changed to the Terre Haute Paper Co. The original facilities at Terre Haute, known as mill no. 1, consisted of one 80-in. cylinder machine, producing straw wrapping paper and corrugating medium. Because of the growth of the corrugated box industry, a second machine was added in 1907 and production devoted entirely to corrugating medium. About 1917 another paper mill was completed in Terre Haute with one paper machine, and another machine was added in 1921. This mill, originally known as mill no. 2, is the present Terre Haute mill, the mill no. 1 having been discontinued in 1951 and converted to its present use as a warehouse facility.

The Terre Haute mill, located on the east bank of the Wabash River at the southwest edge of Terre Haute, consists of two paper machines of 110 and 126 in. trim width and produces about 140 tons of 9-pt. corrugating medium daily. It provides all of its own water supply from deep wells and generates the major part of its own electrical needs, utilizing the readily available supply of Indiana coal trucked directly from nearby mines.

Originally designed to utilize the abundant supply of Wabash Valley wheat straw, the Terre Haute mill has long maintained a reputation for producing the finest quality straw corrugating medium under its "Red Stripe" trademark.

In addition to the mill at Terre Haute, the Mill Division also operates a paperboard mill at St. Marys, Ohio, known as the Auglaize mill, producing high-grade jute linerboard and some specialty grades. This mill is especially noted for its recent development of "Wesbrite," a mottled white liner. The Auglaize mill was originally acquired by Weston in 1907, having previously been the Western Strawboard Co. It then operated as the Auglaize Boxboard Co. until 1947, when this company was merged into the parent firm.

In 1945 the Weston Co. acquired the stock of Wabash Fibre Box Co., a Terre Haute box manufacturer, with which it had long been been closely associated. Wabash Fibre, founded in 1924 by Ward S. Hubbard and originally consisting of the one Terre Haute box plant, operated as a wholly-owned subsidiary of Weston until 1959, when it was merged into the Weston corporation, becoming the present Wabash Fibre Box Co. Div. of the Weston firm.

In 1955 the Wabash Div. erected a new 130,000 sq. ft. corrugated box plant in southwest Chicago. And early in 1961, a new box plant has been completed in Fort Wayne, Ind.

With completion of the Fort Wayne plant, the overall Weston operations will consist of the five manufacturing locations, plus the corporate accounting offices still maintained at Dayton, Ohio. The general management and sales offices, including board sales, are presently located in Terre Haute.

TERRE HAUTE SEMICHEMICAL MILL

The new neutral sulfite semichemical pulp mill, utilizing native Indiana hardwoods, has been successfully placed in full operation at Terre Haute, Ind.

The new pulp mill, which converts the entire production of the plant from the use of straw to hardwoods, includes the latest equipment available for unloading, handling, debarking, chipping, cooking, and refining of pulpwood, and is said to be the most modern such pulp mill built to date.

Designed to produce 150 tons of pulp daily, the new system involves the extensive use of electrically sequenced and remote control mechanisms for automatic operation.

The installation is somewhat unusual in that the new wood process was built adjacent to and tied in to the existing system, so that the changeover from straw to wood has been accomplished without any interruption in the plant's production of 9-pt. corrugating medium.

Designed and constructed by The Rust Engineering Co., in conjunction with Weston engineers, the new pulp mill is currently producing a high quality of unbleached semichemical pulp to the mills two paper machines of 110 and 126 in. trim width at the Terre Haute site.

Weston, like other volume users of straw fiber, in recent years had been faced with a declining availability of raw material within the immediate area of its mill. As a result of changed wheat harvesting methods, acreage allotments, and the use of short stemmed wheat varieties, along with rising farm labor and transportation costs, the availability and profitability of wheat straw had become so closely related to seasonal weather conditions that it became necessary to seek an alternate raw material source.

In 1956, the company management, cognizant of industry developments in the use of hardwoods, undertook measures to determine the feasibility of a neutral sulfite semichemical pulp mill at Terre Haute.

After extensive surveys had satisfied the management that a perpetual supply of native hardwoods was available within a 60-mile radius of Terre Haute, actual planning was begun in 1958. A. D. Meighen, assistant plant manager and technical director, and E. A. Rinell, division engineer, were assigned the responsibility of selecting the process equipment lineup best suited to the specific situation. On the basis of actual visits to existing installations throughout the United States and analysis of proved process equipment, with particular emphasis on dependable performance and maintenance costs, selections were made and cost estimates prepared. Early in 1960 The Rust Engineering Co. was given the job of detailed engineering and the general contract for construction, and the first roll of semichem was produced in March of 1961.

Pulpwood of all deciduous species except walnut, hickory, black locust, and hedge, is being received daily in 6-ft. lengths with diameter specifications of 5 to 16 in. Current shipments are by truck, although rail facilities are also available. The pulpwood is handled in the wood yard by a Pettibone-Mullikin Cary-Lift, or by an American Crane with an Owen grapple, and placed either directly in the debarker chain conveyor apron or to yard storage. An approximate 3-month supply is maintained in the yard. Logs are debarked in a fiber making process three-drum mechanical debarker with a drum speed of 6 r.p.m. and a capacity of 25 to 35 cords per hr.

The debarked logs are chipped in a D. J. Murray 90-in. diam., 10-knife machine, operating at a speed of 400 r.p.m. and then fed at a uniform rate over an Orville-Simpson screen with two screening surfaces. Rechipping and rescreening is provided for rejected chips. Accepted chips of $^5/_8$ in. are conveyed by an inclined belt conveyor to a bucket elevator leading to the chip storage silo, which is 35 ft. diam. and 80 ft. high.

Chips are removed from the silo on a 12 ft. 6 in. diam. Link-Belt rotary table feeder with a variable speed drive which is automatically regulated by a weight controller mounted on the chip bin located above the Pandia continuous digester. The digester is a continuous-type unit consisting of two Chemipulper digester tubes of 42 in. diam., each 38 ft. 10 in. long. The chips are cooked 16 min. at 170 p.s.i. steam pressure and consume 12% sodium sulfite.

The basic refining equipment includes two 40-in. double-revolving disk Bauer primary refiners, one 8 by 16 ft. Impco two-drum vacuum washer, and two Bauer secondary refiners identical to the primary refiners. Stock to the secondary refiners is diluted to 10 to 12% consistency and discharged directly into a 25 ft. diam. by 37 ft. 6 in. high tile chest. The tile chests for the pulp mill were built by the Stebbins Engineering Co., and the high density storage chest is equipped with an Impco dilution system and agitator.

The stock from the high density storage chest is further refined in a Bauer Model 441-F, 44-in. pressure-type disk tertiary refiner and discharged into either one of two tile tertiary stock chests. Combined capacity of the tile tertiary storage chests is 16 tons at 4.5% consistency, which allows ample time for routine maintenance such as plate changes in the refiner.

A part of the mill's production of 9-pt. medium is used by the firm's Wabash Fibre Box Co. Div. with corrugated box plants at Terre Haute, Chicago, and Fort Wayne, with a major portion being sold on the open market. The firm's Mill Division also operates a board mill at St. Marys, Ohio, producing jute liner.

Educational Institutions

The Institute of Paper Chemistry

Bachhuber Appointed Supervisor of Machine Computation

John Bachhuber has been appointed supervisor of machine computation at The Institute of Paper Chemistry. He will be responsible for the scheduling and use of The Institute's computer facilities, programming the equipment, and maintenance of the program library. He is also secretary of The Institute's Computer Committee.

Sixteen Complete Fiber Microscopy Course

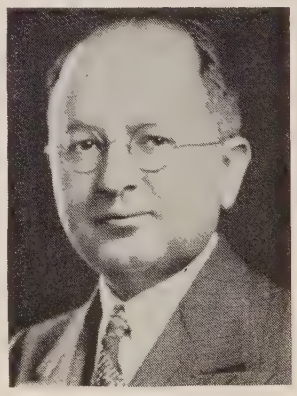
Representatives of 16 companies in eleven states and Canada completed a two-week Fiber Microscopy Course at The Institute of Paper Chemistry, Appleton, on Friday, April 28, 1961. Director of the course was I. H. Isenberg, research associate at The Institute of Paper Chemistry.

Patent Issued to Staff Member

A patent for the extraction of para-hydroxybenzoic acid from the cabbage palmetto, and other palm trees, was issued May 9 to Dr. Irwin A. Pearl, chief of the lignin chemistry group. Previous to Dr. Pearl's work, the acid was not known to exist in any tree, and had been produced synthetically only. The acid has wide use in the production of synthetic fibers of the polyester type, and is used also in the manufacture of cosmetics, gums, mucilage, and in other capacities as a nonfood preservative.

New York University

Morris C. Dobrow, executive secretary of the Writing Paper Manufacturers Association, was the recipient on May 10 of a New York University Madden Memorial Award. The awards, honoring the late Dean John T. Madden, are given to Commerce Alumni "whose careers have exemplified outstanding achievement in business, industry or professional life."



Morris C. Dobrow, Writing Paper Mfgr. Assoc.

Syracuse

Golden Anniversary

Twenty outstanding leaders in forestry and conservation were honored during the golden anniversary observance of

the State University College of Forestry at Syracuse University on April 12, 13, and 14, 1961. During the Forestry College's three-day celebration, five separate symposia were held, four sessions of which were scheduled concurrently.

Altogether, about 1100 persons attended the 50th anniversary activities, according to conservative estimates.

A special program for the ladies was held. Included were special luncheons; campus tours, and tours to points of special interest in and around Syracuse; entertainment by Saengerbund, the College of Forestry glee club, and the international dancers from Syracuse University; a one-woman show consisting of interpretations of the Broadway plays "Gypsy" and "The Sound of Music" by Bea Solomon of Syracuse, etc.

As part of the institution's 50th anniversary observance, a 400-page book on the 50-year history of the college was published by the Alumni Association of the College of Forestry. Copies are being furnished free of charge by the college to all high school libraries in New York State and to forestry college libraries in the United States, Canada, and Europe. The larger public libraries in New York State will also receive free copies of the book from the college. The college's history may be purchased from Dr. Jack L. Krall, treasurer of the Forestry College Alumni Association, c/o the College of Forestry, for $8 a copy.

To mark the special occasion, the 18 symposia papers and the principal speeches delivered at the golden anniversary observance will be published by the college in a bound volume to be distributed this coming summer. Single copies will be available upon request.

Gray Named Adjunct Professor

Dr. Hardy L. Shirley, dean of the State University College of Forestry at Syracuse University, announced that Harry M. Gray, president, Empire State Paper Research Associates, Inc. (ESPRA), and vice-president and director of manufacturing, Sealright-Oswego Falls Corp., Fulton (N. Y.), has been appointed to the faculty as adjunct professor, Pulp and Paper Technology. Mr. Gray will continue in his present capacity at Sealright-Oswego Falls Corp. As adjunct professor, Mr. Gray will be called upon as a guest lecturer at the College of Forestry, and as a special counselor to the College with respect to research and technical problems in the pulp and paper field.

Mr. Gray becomes the 50-year-old college's first adjunct professor—and the first adjunct professor the State University of New York has ever had.

Author of numerous articles published in professional and technical publications, Mr. Gray has affiliations with a number of professional organizations, including the American Pulp and Paper Association, the Paper Industry Management Association, the Technical Association of the Pulp and Paper Industry, and others.

Hardy L. Shirley, left, dean, State University College of Forestry at Syracuse University, installs Harry M. Gray, right, as adjunct professor, pulp and paper technology, at the College of Forestry. Participating in the installation ceremony at the college's campus are: Bernhard K. Mayer, second left, vice-president, ESPRA, and assistant director of research, Oxford Paper Co., Rumford, Me.; and James J. Eberl, second right, secretary-treasurer, ESPRA, and director of research, Scott Paper Co., Philadelphia, Pa.

University of Wisconsin

Merrill A. Scheil Given Citation

On May 5, 1961, the University of Wisconsin, upon recommendation of the faculty of the College of Engineering and with approval of the Regents of the University, recognized the eminent professional services of Merrill A. Scheil (TAPPI Member), in a citation for outstanding accomplishments as engineer, author, and administrator, who, through technical papers and lectures, effective leadership in many technical organizations, and contributions to national defense, has significantly advanced the profession of metallurgical engineering.

Industry Suppliers

Allied Chemical Corp.

Solvay Process Div.

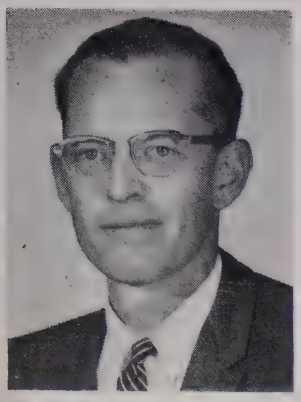
Appointment of Charles E. McGinn as assistant director of research for Solvay Process Div., Allied Chemical Corp., has been announced.

The division recently emphasized an acceleration of research activities with the announcement of a major expansion of the Solvay Research Laboratory, which will double the size of existing facilities. Among the special laboratories being enlarged to meet research and customer requirements are those for studies in pulp and paper, corrosion, and plastics.

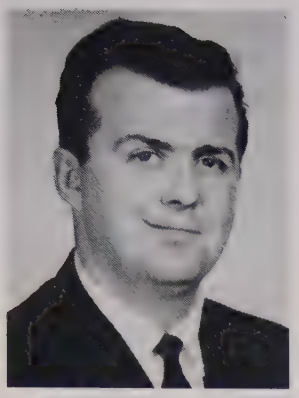
Louis Allis Co.

The Dynapar Corp., subsidiary of The Louis Allis Co., has

Participants are shown at Albany Felt Co.'s two-day round table on fine paper suction transfer machine operations held at Albany, N. Y., plant. Seated left to right: William Emory, Fraser Paper, Ltd.; Richard W. Martinek, Kimberly-Clark Corp.; A. E. Dennard, Champion Paper and Fibre Co., Canton, N. C. Standing left to right: Donald Moritz, Crown Zellerbach Corp.; Judson Hannigan, International Paper Co.; Z. J. Chagnon, Albany Felt Co., Albany, N. Y.



John S. Nelson, American-Marietta Co.



Robert R. Scherer, Appleton Woolen Mills

recently published a 4-page bulletin, No. 203, on type A and type B digital draw indicators. Dynapar utilizes transistorized indicators, provides precise draw or speed measurement, eliminate calibration and drift, assure positive readout and trouble-free operation for paper machines and other similar applications.

Type A indicators have a maximum capacity of five draws or speeds. Type B offers as many as 50 draws or speeds, for roll speeds up to 4000 f.p.m. as standard with higher available.

Write The Louis Allis Co., Dept. P, 427 E. Stewart St., Milwaukee 1. Wis.

American-Marietta Co.

A. W. Hendry, general sales manager of the Adhesive, Resin & Chemical Division, American-Marietta Co., Seattle, Wash., announced the appointment today of John S. Nelson as sales representative for A-M products used by the paper industry in the Wisconsin area. He will reside in Appleton, Wis.

American SF Products, Inc.

Englewood Cliffs, N. J., is the new home of American SF Products, Inc., manufacturers of airdrying and ventilation equipment. The company, which was previously in the Graybar Building, New York City, will occupy offices at 701 Palisades Ave., Englewood Cliffs, N. J. The phone number is LOwell 7-6555.

Among the products manufactured by American SF are the air-borne Flakt Drier, Type L, for pulp, as well as pulp coolers, flue dampers, constant humidity units, and similar equipment for the paper field and the processing industries.

Appleton Woolen Mills

Appleton Woolen Mills has appointed Robert R. Scherer as Mid-Atlantic states' sales representative, effective immediately. Mr. Scherer's territory will consist of Pennsylvania, New Jersey, Delaware, Maryland, and a portion of New York State.

Carl N. Beetle Plastics Corp.

The Carl N. Beetle Plastics Corp. is now engaged in the manufacture and sale of hoods for paper machines. This business was formerly conducted by Mead Pulp Sales, Inc., New York, N. Y. Under the new arrangement, the facilities of Mead Pulp Sales, Inc. will be actively identified with the distribution and sales promotion. George H. Cash, formerly with Mead Pulp Sales, Inc., is now associated with Beetle Plastics and is responsible for the sale of hoods for paper machines with offices at 77 Bedford St., Stamford, Conn.

John W. Bolton & Sons

A. L. Bolton, Jr. has been elected president of John W. Bolton & Sons, Inc., and The Emerson Manufacturing Co., Div., Lawrence, Mass. Bolton-Emerson is a leading manufacturer of stock preparation machinery and equipment for the pulp and paper industry and machine knives for most major industries.

Wallace L. Bolton has been made manager of manufacturing and Robert C. Holland, production manager over all plant operations of John W. Bolton & Sons, Inc., and The Emerson Manufacturing Co., Div. at Lawrence, Mass.

Richard L. Boll has been appointed sales engineer serving paper mills in the southwest for John W. Bolton & Sons, Inc., and The Emerson Manufacturing Co., Div., Lawrence, Mass., it was announced by F. Richard Convey, General Sales Manager. From headquarters in Louisiana, Mr. Boll will work under Robert P. Calvert, Bolton-Emerson's Senior Sales Engineer in the Southern Region.

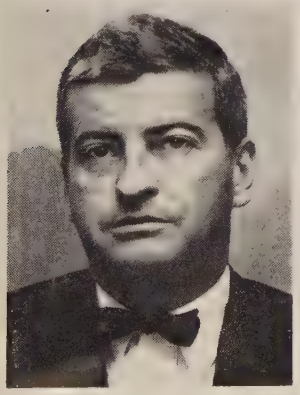
Bristol Co.

A new line of 4-in. chart Metagraphic pneumatic receivers has been announced by The Bristol Co., Waterbury 20, Conn. Built to a completely new design, these instruments, designated as the Series 670, are best described as being user oriented. Many new features, both standard and optional, combine to make the Series 670 easy to install, easy to use, and easy to maintain. Nine models are presently available to meet any control requirement.

Clinton Corn Processing Co.

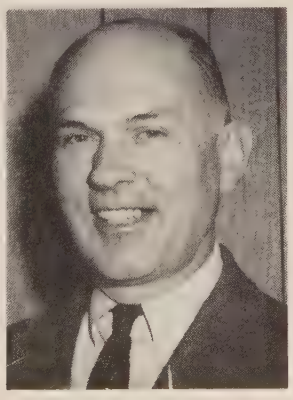
Joel S. Mitchell, chairman of the board of Standard Brands, Inc., announced today that Harold A. Bendixen had been elected president of Clinton Corn Processing Co., a division of Standard Brands. Mr. Bendixen succeeds Roscoe C. Wagner who retired on May 1, 1961, after 41 years of service with Clinton.

Announcement was also made of the promotion of Reynold P. Jurgensen as senior vice-president of Clinton with con-



A. L. Bolton, Jr., John W. Bolton & Sons, Inc.

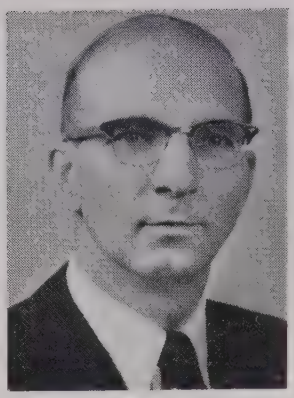
Wallace L. Bolton, John W. Bolton & Sons, Inc.



Robert C. Holland, John W. Bolton & Sons, Inc.

Richard L. Boll, John W. Bolton & Sons, Inc.

tinued responsibility for production, engineering, operating, traffic, personnel, purchasing, and research.



Harold A. Bendixen, Clinton Corn Processing Co.

E. I. du Pont de Nemours, & Co.

"Baymal" colloidal alumina, a versatile addition to the inventory of basic chemicals available to industry, has been announced by du Pont's Industrial and Biochemicals Department.

Research chemists who developed "Baymal" say it has more unique properties and use possibilities than any chemical to emerge from their laboratories in many a year. To illustrate this versatility they point to the fact that in one form "Baymal" is hard enough to machine steel or cut glass, while in another form it can be used to improve the smoothness of a skin lotion.

Chemically, "Baymal" is a white, free-flowing powder, consisting of clusters of minute fibrils of boehmite (AlOOH) alumina.

The product owes its wide spectrum of potential applications to the following combination of properties:

1. It is a water dispersible powder. Baymal disperses and swells up in water to form a stable colloid.

2. It consists of fibrillar particles. When a colloidal dispersion of Baymal is dried from water onto a surface, the small fibrils lie flat and interlace to form a film. Very few inorganic materials and no other aluminas form films in this manner. Such films remain stable at high temperatures.

3. Particles of "Baymal" are extremely small and have a high surface area. If the fibrils in 1 lb. of Baymal were laid end to end, they would make 25 round trips to the sun. The surface area of these same fibrils would cover 30 acres.

4. When dispersed in water, fibrils of Baymal colloidal alumina assume a positive charge. Because of this positive charge, Baymal can fix itself to negative surfaces such as glass, paper, clay, etc., completely changing their surface charge from negative to positive.

5. Baymal is hydrophilic and organophilic. Because it is wet both by water and certain organic liquids, Baymal can act as an emulsifier and a thickening, dispersing, and suspending agent in both water and water-alcohol systems.

6. Baymal has a low toxicity. du Pont is applying to the Food and Drug Administration currently to obtain clearance for the use of "Baymal" in cosmetics and pharmaceuticals.

A dilute solution of "Baymal" in water assumes viscosity characteristics that are most unusual. A 4% dispersion, for example, can be changed from a very fluid solution to a very viscous sol or paste through a slight change in acidity. These viscous sols and pastes are highly thixotropic. In such a state, a gel remains in solid form until shaken or agitated, which causes it to turn into a liquid. On being allowed to stand, the liquid again becomes a solid gel. This reversible transformation can be reproduced any number of times, and the time required for the gel to set up can be tailored from less than a second to more than a day. du Pont claims that "Baymal" is the most thixotropic material known to them.

"Baymal" is now being produced in developmental quantities at du Pont's Belle, W. Va., plant. A limited supply of 1-lb. samples is available, and larger quantities are being sold at $3.50 per lb. The price is expected to be reduced substantially as production facilities and commercial use expands.

Foxboro Co.

The Foxboro Co., Foxboro, Mass., has announced the completion of a new instrument manufacturing and assembly building at the Foxboro (Nederland) N.V. plant in Soest, Holland. The new facilities, now in operation, were dedicated during an Open House ceremony held on May 2.

The new structure, which gives the plant a total area of nearly 40,000 sq. ft. will permit a substantial increase in the production of standard Foxboro instruments supplied to industries in the European Common Market. Production of d/p Cell Transmitters will be expanded along with manufacture of pneumatic panel-type Consotrol instruments, valve motors, and basic temperature and pressure instruments.

Architect's drawing of Foxboro (Nederland) N.V. plant in Soest, Holland which was opened on May 2nd

Addition of the new building has freed space in the original plant for a training center, maintenance facilities, and storage areas, and will also enable the company to increase its maintenance, repair, and parts services for European instrument users.

French Oil Mill Machinery Co.

The intense pressure and fiber-to-fiber contact that takes place in the new French screw press, designed and built by the French Oil Mill Machinery, Piqua, Ohio, increases headbox freeness 20 to 25% in pulp processing operations, yet maintains desired sheet properties. The added efficiency provided by this press has resulted in substantial savings for many leading pulp and paper mills.

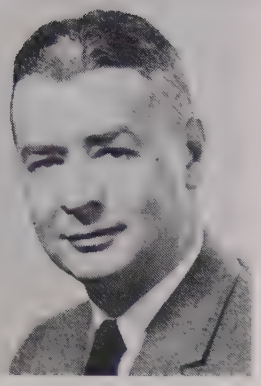
The French screw press is designed to express fluids from fibrous materials, defiber and shred whole wood chips and squeeze spent liquor from treated chips. With a barrel length of 77 in., almost twice that of smaller units the press can attain up to 90% liquor recovery in a single pass. This is almost 30% more liquor recovery than is permitted with smaller machines with shorter barrels. The high recovery in a single press is possible because the 77-in. barrel makes it possible to add wash water in the middle and realize two-stage pressing in one machine.

General Electric Co.

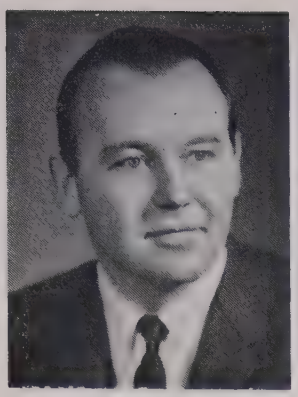
Matthew T. Finn has been named manager of paper and light industries sales for the General Electric Co., according to an announcement by C. B. Elledge, manager of the industrial sales and engineering operation. In his new position, Mr. Finn will direct the sale of the company's products and systems to the paper, textile, plastic, printing, food, and associated industries.

Glidden Co.

Robert E. Lehman and J. Corson Smith have been appointed national accounts representatives for the Pigments and Color Dept. of the Glidden Co.'s Chemicals Div.



Robert E. Lehman, The Glidden Co.



J. Corson Smith, The Glidden Co.

Messrs. Lehman and Smith will headquarter at the home office of Glidden's Chemicals Division in Baltimore.

Great Lakes Carbon Corp.

The Dicalite Dept. of the Mining & Mineral Products Div. of Great Lakes Carbon Corp., Los Angeles, Calif., has been appointed exclusive sales representative, particularly in the filtration field, for Solka-Floc, a cellulose filtering agent manufactured by the Pulp & Floc Div. of Brown Co., Berlin, N. H.

The Dicalite sales organization, best known for its diatomaceous earth and mineral filtration materials, will begin selling Solka-Floc effective immediately. Territory included in the agreement takes in all 50 United States and Canada. Dicalite products are currently sold through a direct sales force and agents covering both countries.

Although the activity of the Dicalite sales force will be chiefly concerned with filtration problems, under the arrangement they will also develop new applications for Solka-Floc. Brown representatives will continue to sell customers for specialized applications for such industries as welding, chemical, pharmaceutical, food, rubber, plastics, and flocking.

W. & L. E. Gurley

Stiffness Tester

A factor table is now attached to the Gurley stiffness tester as standard equipment. This etched aluminum plate with convertible scale readings to milligrams of stiffness will eliminate the problem of the mislaid data card, formerly a problem in laboratories.

The factor table, which can be attached to previously purchased instruments, is also being offered free of charge to each owner of a Gurley stiffness tester. A table, and instructions for its use, will be forwarded free of charge to each owner who sends in the serial number of his instrument along with name and address. The etched aluminum factor plates can be purchased by other individuals at one dollar each. Write: Industrial Division, W. & L. E. Gurley, Troy, N. Y.

Hanchett Manufacturing Co.

A recent development of the Hanchett Manufacturing Co. of Big Rapids, Mich., this grinder fills a major requirement of the flake board producer.

The finest edges are generated on both the high and recessed faces of these serrated knives with speed and precision. The unique design of this machine includes the automatic in-feed and retraction of the grinding head to develop a fine edge on the recessed faces of the knives. Longer edge life, fast re-grinding and accurate production of flakes aid greatly to bring out the fullest efficiency of the board mill.

This machine is an adaptation of the Model GK Grinder, long accepted for its rugged durability and precision accuracy. Arranged for easy removal and replacement of the grinding wheel without disturbing spindle bearings. Spindle is high carbon steel mounted on ball bearings.

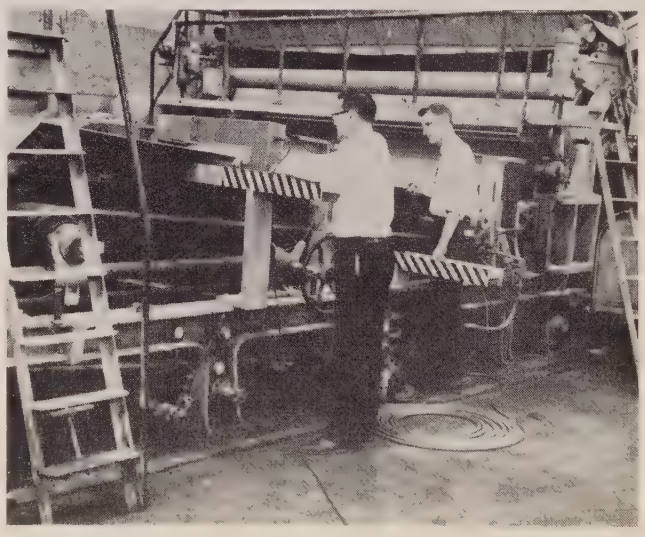
Huyck Felt Co.

The Huyck Felt Co. has announced the establishment of a new type of service for the paper industry. This pioneering effort has placed qualified research and development personnel in the Portland, Ore., area, to serve paper mills on a continuing basis.

The purposes of this unique Huyck program are to study the various phases of felt and press operation, the factors influencing sheet finish, size, stability, water removal, and the felt's ability to "couch" or pick up. Emphasis is also placed on the felt as a sheet conveyor and power transmission belt. The entire resident engineer field effort is supported by a team of scientists, engineers, and highly qualified consultants working in Huyck's Science Center, located in the Rensselaer, N. Y., plant.

After the collection of adequate instrumental data on the fluid dynamics of press operations, an analysis will be made detailing preferred changes in felts and press section particulars. Recommendations for machine adjustments such as changes in press loading, roll crowns, couch positions, felt tension and felt cleaning will be made. Not only will more fundamental information be uncovered about the function and mechanisms of water removal by papermakers' felts but advantages in the form of better water removal and improved paper quality are anticipated for the cooperating paper mills.

Huyck Felt has assigned two resident engineers to the Portland, Ore., area to provide extensive scientific and technical support to a series of engineering investigations of machine wet end operations.



Huyck's Bill Welch using Huyck's beta ray gage and Don Baade using Huyck's measuring wheel to check press water removal efficiency

J. William Welch has been appointed senior resident engineer, and will be assisted by Donald Baade, junior resident engineer. This new research and development program will be offered as a supplement and in addition to the regular services now provided by Huyck's regional sales manager, Roy W. Keller and field service engineer, Robert D. Baer.

Huyck's resident engineer program is currently being conducted in the plants of cooperating companies using an extensive array of instrumentation. It will be extended to other mills in the Portland, Ore., area which are interested in a cooperative engineering and instrument approach to felt and press problems.

Claude A. Raby, J. M. Huber Corp.

Howard W. Bartlett, Keever Starch Co.

J. M. Huber Corp.

Claude A. Raby has been named divisional manager for sales of J. M. Huber Corp. paper clays and pigments. Mr. Raby, who has served as assistant divisional manager since April 1, 1956, succeeds Robert J. Casey who has resigned. Mr. Raby will have sales headquarters at 630 Third Ave., New York City.

INTERNATIONAL CLAY CO.

J. M. Huber Corp. has acquired the assets of International Clay Co., Graniteville, S. C., it has been announced by Michael W. Huber, president. Mr. Huber stated that this acquisition will add to Huber's resources of kaolin clay. International Clay Co.'s mine and properties adjoin Huber's largest mine in South Carolina.

I-T-E Circuit Breaker Co.

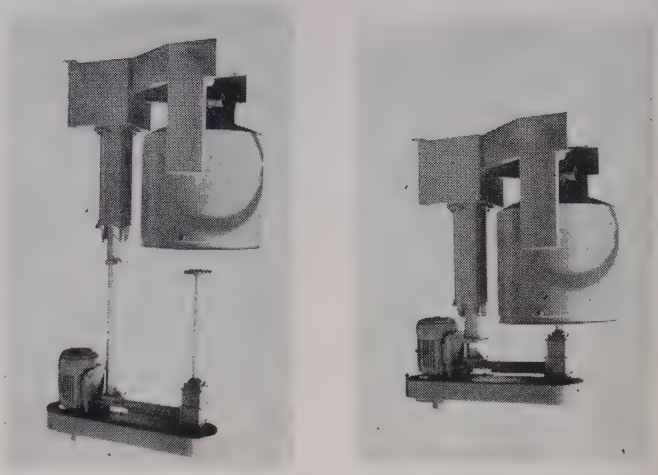
Advanced design features of 600-v. switch-gear with K-Line circuit breakers are described in new two-color bulletin published by I-T-E Circuit Breaker Co., 1900 Hamilton St., Philadelphia 30, Pa. The 20-page bulletin, No. 3200-1A, provides comprehensive information on low voltage power circuit breakers and switchboards, ranging in unit ratings from 225 to 4000 amp.

Keever Starch Co.

Appointment of Howard W. Bartlett, as manager of the Paper Div. of the Keever Starch Co., has been announced. As manager of the Paper Division, he will be responsible for all sales and technical service of Keever products to the paper and corrugating industry. Headquarters for Mr. Bartlett will be the home office of The Keever Starch Co., Columbus, Ohio.

Kinetic Dispersion Corp.

Kinetic dispersion corporation announces a new addition to its increasing line of high-speed mixing equipment. To be known as the "Multi-batch Kadyzolver," this unit can be equipped with one (as shown) to four water or steam jacketed vessels of up to 300 gal. capacity, each equipped with Kady remote air control dump valves of 4 in. capacity. With this arrangement a single mixer can be raised and swung into a succession of vessels, allowing for a continuous draw of intensive mixed material as tanks are alternately loaded, mixed, and drained off to further processing or filling needs. Similar larger units up to 75 hp. and tank groups of 1000 gal. each with 6-in. opening flush bottom valves are also available. These units can also be furnished with all-stainless new high-efficiency high velocity jackets for ultrafast heat exchange purposes.



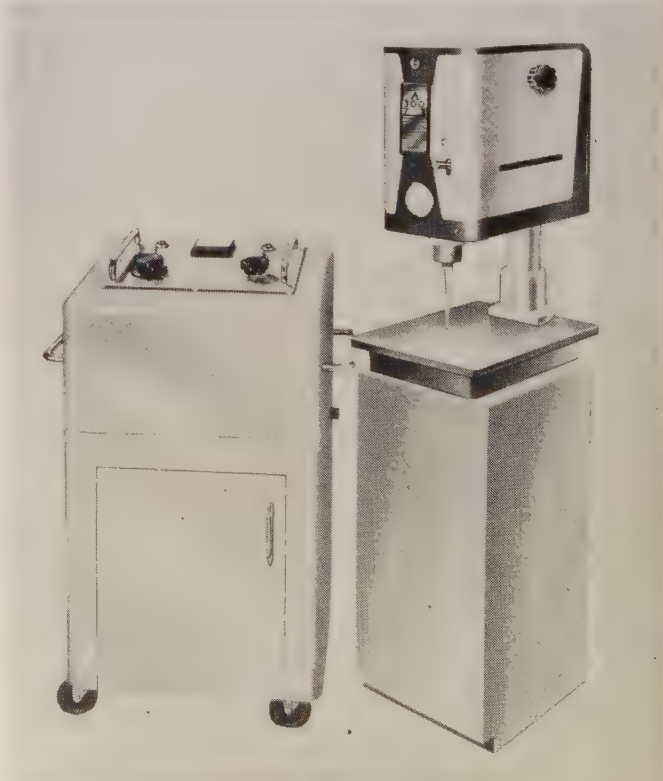
Multi-batch Kadyzolver in the up (left) and down (right) positions

Kleer-Vu Industries, Inc.

ULTRA SONIC SEAL, INC.

A new industrial tool, utilizing ultrasonic energy for the sealing of plastic film and synthetic fabrics, has been introduced by Ultra Sonic Seal, Inc., a division of Kleer-Vu Industries, Inc., of New York.

Fundamental principle on which the sealer operates involves the use of ultrasonic impulses. Moving at the rate of 20,000 vibrations per second, the operating tool welds plastics by releasing kinetic energy within the material joined. The imperceptible vertical movement of the tool in contact with the plastic generates heat internally between the sandwiched layers of material, creating a natural molecular bond. Any heat that is generated dissipates into the cold mass of the anvil and the operating tool, leaving the outer surfaces of the material cool.



Shown above is ultra sonic sealer, designed Zephyr "300," new industrial tool which utilizes ultrasonic energy for sealing of plastic film and synthetic fabrics

Welds can be made continuously or intermittently on overlapped pieces of plastic. However, a simulated "butt" joint can be accomplished by using a modified technique. This involves employing a larger area tool, but obtains energy concentration by a very narrow lap of the two butted ends.

Ultrasonic plastic welding is probably the most versatile type of sealing principle available. It can seal practically all materials that are generally considered sealable by conventional heat and dielectric equipment, but eliminates many of the disadvantages of standard techniques.

The sealer can successfully bond Mylar polyester, nylon, vinyl, polyethylene, polypropylene plastic coated papers and foils, synthetic fabrics, and many other thermoplastic materials.

Lodding Engineering Corp.

The first of a series of concentrated, one-day seminars on proper doctoring procedures was held April 19, 1961, at the Auburn, Mass., plant of Lodding Engineering Corp., the world's leading specialists in the manufacture and installation of machine roll doctors and auxiliary equipment.

Attended by representatives of Crane & Co. and Byron Weston Co., Dalton, Mass.; Hurlburt Paper Co., South Lee, Mass., and Oxford Paper Co., Lawrence, Mass., the seminar was offered by Lodding as service to help mill maintenance personnel gain a better understanding of the requirements for good doctoring.

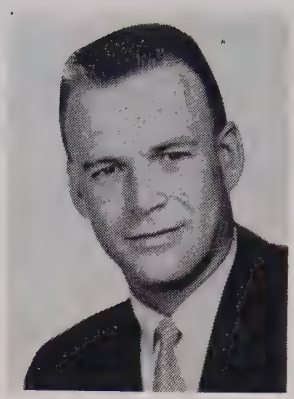
The program was characterized by informal presentation, demonstration, and periods of general discussion. Under the direction of James K. Gardner, marketing manager and Joseph S. Cooper, field service manager, the day's program, among other subjects, covered: a discussion of good doctoring, detailed procedures for installing a doctor, analysis of blade wear patterns as a means of determining doctor operation; and proper utilization and maintenance of hydraulic and mechanical oscillation and pressure rigs.

Those attending the seminar were presented portfolios containing illustrated technical information covering the topics discussed. A tour of manufacturing facilities and the experimental testing laboratory was included.

A number of similar day long seminars will be held in mills on the West Coast during May. Other areas of the country will then be visited. Mills interested in having their engineering and maintenance staffs participate in doctoring seminars may make arrangements for doing so through their Lodding sales representatives.

Mill maintenance personnel attending the one-day doctoring seminar at Lodding Engineering Corp. Seated around table, from left to right, are: Alan Guild and Donald W. Lafreniere, Oxford Paper Co.; Clarence A. Baldwin, Donald A. Beebe, Maurice Roberts, and Frank Koloski, Hurlburt Paper Co.; Harold Irish, Byron Weston Co.; Harold Elser, Isadore Plant and Edward Elser, Crane & Co.; and Warren Lutz, Oxford Paper Co. Standing, l. to r., are Joseph S. Cooper, field service manager and James K. Gardner, Lodding marketing manager, who jointly conducted the seminar

Michael Pavol, Minerals & Chemicals Philipp Corp.



James L. McAndre, Morden Machines Co.

Midland-Ross Corp.

Ross Midwest Fulton Div.

The Ross Midwest Fulton Div. of Midland-Ross Corp., 3320 South Dixie Highway, Dayton 39, Ohio, has available, free on request, a four-page bulletin describing their Hydroscillator units for the paper industry. The bulletin, number RMF-501, describes how the flexible units eliminate mill roll wrinkles at the winder, and includes photos, descriptions, specifications, drawings, and operational data on the models available.

Minerals & Chemicals Philipp Corp.

Minerals & Chemicals Philipp Corp., Menlo Park, N. J., has announced the appointment of Michael Pavol to the new position of technical service representative to the paper industry. In this new assignment, Mr. Pavol will work exclusively with the paper industry to provide technical service for MCP's filling and coating clays, as well as develop new applications for lime and attapulgite products in the pulping, water treatment, and pitch control fields.

Morden Machines Co.

James L. McAndie has been appointed Northeastern sales engineer for Morden Machines Co. of Portland, Ore. McAndie is being transferred from Portland where he has served as West Coast representative for the past two years. Mr. McAndie will make his headquarters in West Acton, Mass., and will officially take over June 7, 1961. Morden Machines Co. has been represented since 1948 in the Northeast by Orton Corp., of Fitchburg, Mass.

Nalco Chemical Co.

Foam Control

Effective foam control in pulp and paper mill systems is the subject of new process bulletin, F-1, offered by Nalco Chemical Co., 6216 West 66th Place, Chicago 38, Ill. Antifoam requirements, characteristics, and methods of application are discussed, with emphasis on how they can be employed to improve sheet formation and mill operating conditions.

Sodium Aluminate

Advantages of using papermakers' sodium aluminate, as an aid to sizing and a flocculation agent, are described in a new process bulletin, P-3, also available from Nalco Chemical Co. Dealing with product quality and operating conditions, the brochure graphically illustrates how sodium aluminate

can improve efficiency in a broad range of paper mill operations. In addition to discussions of alumina-acid content, filler retention, foam and corrosion control, an insert describing preparation and application methods of the solution is included.

National Lead Co.

National Lead Co. has begun construction of a new multimillion dollar research center in East Windsor Township, near Hightstown, N. J. Located on a 250 acre site adjacent to the New Jersey Turnpike, the research center will comprise separate units designed to provide specialized facilities for research and development work for the company's major divisions.

National Lead Co., a leading producer of fabricated nonferrous metals, chemicals, paints, pigments, alloys, bearings, die castings, oil well drilling muds, refractories, and other products for industry, has 90 plants and mines and 16 research and development laboratories located throughout the country, as well as operations in 13 foreign countries.

Construction of the first unit of National Lead Co. Research Center is scheduled for completion in the summer of 1962. The building will contain 87,000 sq. ft. of laboratory, office, and service space. There are four wings which will be devoted to research and development in the fields of nonferrous metals, paints and pigments, lead chemicals, plastics, and resins. The building will also include a cafeteria and a library, as well as service and storage facilities. The present staff of 150 scientists and technicians at the company's Brooklyn Research Laboratories will be transferred to the new center.

New Jersey Zinc

The New Jersey Zinc Co. has named Stanley E. Moore and Robert O. Smith as sales representatives in its pigment division. Mr. Moore has been assigned to the Kansas, Missouri, Arkansas, Kentucky, and southern Illinois territories. Mr. Smith will be active in the Chicago area and Minnesota.

Nopco Chemical Co.

A new wax sizing agent for paper and board, that decreases strength loss by 50% or more and cuts cost as much as 17% over conventional type wax sizes has been developed by the Industrial Div. of Nopco Chemical Co., 60 Park Place, Newark 1, N. J. Developed for use with regular rosin and fortified rosin sizes, the new agent—Nopco Size 1055-V—produces almost no loss in strength of the paper or board.

STAFF

Lawrence O. Strange has been named to handle sales of paper chemicals in two southern states in an expansion of his territory and responsibility for sales of products of the Industrial Div. of Nopco Chemical Co., Newark, N. J.

He will handle sales of chemicals to paper mills in Alabama and Mississippi, assuming the responsibility formerly assigned to James H. Holmes who was recently named southern district sales manager. In addition to his new duties, Mr. Strange will continue to handle sales of the firm's chemicals to paper, textile, paint, and specialty industries in Florida and the southern parts of Georgia and South Carolina.

Pfaudler Permutit, Inc.

IONAC CHEMICAL CO.

A handy maintenance and troubleshooting checklist, covering a wide range of boiler and cooling water system troubles and their recommended treatments has just been published by Ionac Chemical Co., a division of Pfaudler Permutit, Inc., Birmingham, N. J.

The new publication, "Ionac Water Treatment," Bulletin CS 113, includes in easily read chart form a list of 23 common troubles arising from water and fuel contaminants and other causes, and recommends one or more treatments for each. Diagnosis of causes for such troubles as scaling, corrosion, foaming, and others are also listed in the chart.

Also described in the new folder is Ionac's five-point service program which includes laboratory water analysis, plant survey, recommendations, service checkup, and control aids in addition to providing the exact chemical aids for treatment of a variety of boiler plant troubles.

Penick & Ford, Ltd.

The appointment of Ernest C. Cowell as paper mill representative for Penick & Ford, Ltd. is announced by W. S. Russell, Sales Manager—Corn Refining Division. Mr. Cowell will call on paper mills in the Central District. He joined the company in February, 1961, with experience in quality control, research engineering, and customer service work for manufacturers of paper and paperboard.

Ernest C. Cowell, Penick & Ford, Ltd.

Philadelphia Quartz Co.

Just a few years before the start of the Civil War, the Philadelphia firm of Joseph Elkinton & Son, later to be known as the Philadelphia Quartz Co., began experimenting with sodium silicate. Since the founding of the firm in July, 1831, soap and candles had been its only products, but news from abroad that sodium silicate had value as a detergent builder for soap was intriguing. Experimental work proved that it was very beneficial to the qualities of Elkinton's soap products and before long other soap makers wanted to buy silicate.

A business within a business was developing and the company made its first recorded sale of sodium silicate 100 years ago on Jan. 21, 1861. The Civil War which broke out three months later resulted in embargoes preventing Northern soap producers from procuring Southern rosin, an important ingredient in kitchen and laundry soaps. Silicate as a soap builder consequently came into greater demand and was recognized as an improvement over rosin. Although soap making continued at the original Elkinton plant on South Second St., Philadelphia, it became necessary to expand production for the manufacture of silicate. In 1864 a larger factory was built at Ninth and Mifflin St., and it was then that the name of Philadephia Quartz Co. first appeared.

By the time the nation celebrated its centennial, the company had added a technical representative who could demonstrate how silicate was used in soap. Calling up on a manufacturer, he produced from his satchel, miniature soap making equipment and proceeded to make a small batch of soap in the buyer's presence. Thus, the method to establish proof of the value of silicates, not only in washing, but in other industrial processes, was instituted.

An array of silicate products was now offered, indicating new uses for what was becoming recognized as a versatile chemical. In 1889, growing business in the Mid-West justified the opening of a silicate factory at Anderson, Ind. In 1905 the outdated Philadelphia plant was replaced by a new factory at Chester, Pa., to meet increasing sales demands. It was then decided to concentrate the entire energies of the company on the manufacture and development of silicates.

Today, soluble silicates are used in a wide variety of industries; i.e., soap, detergent, paper, paperboard, textile, refractory cement, oil, rubber, laundry, mining, and foundry. They are used for the prevention of corrosion in water lines,

for concrete hardening, in metal cleaning, in coagulation of raw and waste waters, in the solidification of foundation soil and catalytic gel manufacture.

Currently, the company's literature on soluble silicates covers over 100 different subjects. *Silicate P's & Q's*, the monthly house organ, is dedicated to disseminating information on silicates. It has been published continuously for over 40 years.

The nine Philadelphia Quartz Co. plants are located at Anderson, Ind.; Baltimore, Md.; Buffalo, N. Y.; Chester, Pa.; Jeffersonville, Ind.; Kansas City, Kans.; Rahway, N. J.; St. Louis, Mo.; Utica, Ill. An associated company, Philadelphia Quartz Co. of California, operates plants at Berkeley and Los Angeles, Calif., and at Tacoma, Wash. Another associate is National Silicates, Ltd. with producing units at Toronto, Ont., and Valleyfield, Que.

Raybestos-Manhattan, Inc.

The following new appointments have just been made at a directors meeting of The Manhattan Rubber Manufacturing Co., Neenah, Wis., a wholly-owned subsidiary of Raybestos-Manhattan, Inc. J. N. Kuzmick, vice-president and director. He is also vice-president and director of Raybestos-Manhattan, Inc. R. B. Hazard, director. Mr. Hazard is also vice-president and director of Raybestos-Manhattan, Inc., A. A. Campbell, vice-president. He was formerly resident manager. A. F. Kuehn, Jr., resident manager.

The Manhattan Rubber Manufacturing Co. has been located in Neenah for 28 years serving in particular the paper mills and other industries in the Fox River Valley covering rolls and rubber linings for tanks, pipe and other metal parts. Similar plants are located at Passaic, N. J., and North Charleston, S. C.

Rhodia, Inc.

Rhodia, Inc., New York producer of aromatic chemicals, announced the appointment of William C. Mackie as Midwest district sales manager and Everett J. Weaver as assistant to Mr. Mackie. Formerly West Coast district manager, Mr. Mackie has had more than 20 years' experience in the aromatics field. Mr. Weaver was previously in charge of the southern territory for Rhodia.

Rhodia also announced the opening of larger and more efficient quarters to serve the Midwest market. The new offices are located at 5225 Touhy Ave., Skokie, Ill.

Rohm & Haas Co.

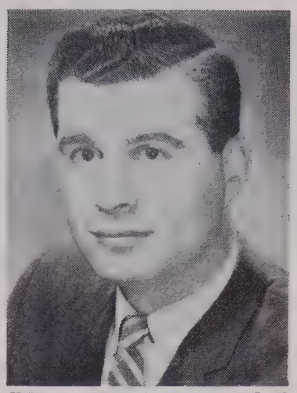
Availability of a new emulsion for paper coating, Rhoplex 9, was recently announced by Rohm & Haas Co., Philadelphia chemicals manufacturer. This product, an acrylic-modified vinylidene-chloride emulsion, is highly stable and has unusually good film-forming characteristics. Applied to paper or paperboard by standard coating methods, this emulsion forms films which offer exceptionally good water, solvent, grease, scuff and block resistance. They also provide an excellent water-vapor barrier.

Roots-Connersville Blower Div.

Roots-Connersville Blower, Division of Dresser Industries, Inc., is offering a complete line of high-vacuum booster pumps for vacuum processing and environmental systems. Roots booster pumps are two-impeller, dry-type units the impellers and seals especially suited to high-vacuum service. They have a wide operating range, with an exceptionally flat pumping speed curve and "blank-off" below 0.5 Hg absolute pressure with pumping speeds to 35,000 c.f.m.

S & S Corrugated Paper Machinery Co.

Edgar B. Lehman, in charge of S & S overseas operations, has just been appointed general sales manager of S & S Corrugated Paper Machinery Co., Inc., Brooklyn, N. Y., according to an announcement by Mitchel Flaum, president. S & S is one of the world's largest manufacturers of machinery for the production of corrugated board and containers. Mr. Lehman's new position will include supervision of both domestic and overseas sales activities, in addition to other duties associated with the S & S overseas operation.



Edgar B. Lehman, S & S Corrugated Paper Machy. Co.

Shawinigan Resins Corp.

Availability of a new vinyl copolymer emulsion which possesses an unusually high degree of inherent tack and adhesion to specific surfaces has been announced by Shawinigan Resins Corp., Springfield, Mass. Designated Resin D-845, the new emulsion provides clear, soft, nonreemulsifiable films and is compatible with borax and various organic solvents. The material is suggested for use in adhesives formulations, particularly those for pressure-sensitive and contact adhesives.

J. E. Sirrine Co.

J. E. Sirrine Co., engineers and architects of Greenville, S. C., have awarded construction contracts for their own new modern office building to be located near the Greenville Airport. Sirrine president, George Wrigley, Jr., announced that completion is scheduled for January, 1962, to coincide with the company's 60th anniversary.

The new Sirrine headquarters will provide 32,500 sq. ft. of air-conditioned office space in a unique two-story design. Total construction and site development costs are reported to be in excess of one-half million dollars. Situated on a 3-acre plot, this building is designed to take full advantage of the natural grade with the site fully utilized to provide attractive landscaping areas and parking facilities for more than one hundred cars.

The design is such that the upper story extends over the ground floor executive office suites to provide a covered walkway on three sides of the building giving an unusual three-dimensional effect, and at the same time shading the large window areas. The building is an exposed structural motif fully expressing the feeling of modern materials. The structure is of white glazed brick and glass featuring a landscaped garden enclosing a reflection pool on the north side of the building adjacent to the ground floor executive offices and conference rooms. In addition to the executive offices, the ground floor area contains the main lobby, employee lounges, Field, Accounting, and Public Relations Departments and all

New office building proposed for the J. E. Sirrine Co., Greenville, S. C.

supporting service facilities, such as blueprinting and duplicating rooms, file rooms, chemical and water treatment laboratories, model shops, etc. The model of the building from which these photographs were made was produced in the Sirrine model shop. In addition to space for 130 drafting boards, the second floor includes conference rooms, a library and 21 offices for department heads, secretaries, project managers, etc.

A wide variety of interior finishes are planned to enhance the feeling of spaciousness; carpeting, resilient tile and stone flooring will alternate in different parts of the building. Masonry, cherry paneling and glass walls and partitions will add further to the pleasing decor. Acoustical tile will alternate with illuminated plastic ceilings to add still further to the quiet and pleasing work conditions designed to promote maximum efficiency.

During the first 35 years of the organization's life its work was primarily in the textile field, and they designed many of the textile mills erected in the South in that period. In addition to textiles, the company designed hydroelectric and steam power plants, tobacco factories, furniture factories, schools, warehouses, institutional and commercial establishments. Later, the company expanded to serve the pulp and paper industry and during the past 25 years have designed many of the new modern plants erected in the South.

J. E. Sirrine Co. offers complete professional engineering and architectural services for every stage of new building construction and modernization from initial field investigation studies, appraisals, and reports through design to the supervision of construction.

J. E. Sirrine Co. is well known for its pioneering work in industrial processes such as chlorine dioxide bleaching of paper pulps. Major chemical process plants designed by Sirrine include:

Bowaters Southern Paper Corp., Calhoun, Tenn.
Buckeye Cellulose Corp., Foley, Fla.
Container Corp. of America, Fernandina, Fla.
Continental Can Co., Inc., Hopewell, Va.; Savannah, Ga.; and Hodge, La.
Coosa River Newsprint Co., Coosa Pines, Ala.
Crossett Paper Mills, Crossett, Ark.
Marathon Southern Corp., Butler, Ala.
Nekoosa-Edwards Paper Co., Port Edwards, Wis.
St. Marys Kraft Corp., St. Marys, Ga.
Southern Chemical Cotton Co., Chattanooga, Tenn.
S. D. Warren Co., Cumberland Mills, Me.
Union Bag–Camp Paper Co., Franklin, Va.
American Thread Co., Clover, S. C. and Sevier, N. C.
Coats and Clark, Inc., Toccoa, Ga.
Cone Mills, Inc., Carlisle, S. C.
Cranston Print Works Co., Fletcher, N. C.
J. P. Stevens and Co., Inc., Delta Finishing Plant, Kollocks, S. C.
Corps of Engineers, U. S. A., Redstone Arsenal, Huntsville, Ala.
South Carolina State Ports Authority, Charleston, S. C.

Square D Co.

Square D Co.'s Class 9050 types B and C timing relays are now available with a new two-pole snap switch which doubles the number of contacts and mounts in the same space as a single-pole timer. The new device is designed for applications where normally it would be necessary to install an extra timer or relay for control of additional circuits. For details, write for Bulletin 9050, Square D Co., Dept. SA, 4041 N. Richards St., Milwaukee 12, Wis.

A. E. Staley Mfg. Co.

A new research center was opened by the A. E. Staley Manufacturing Co., Decatur, Ill., dedicated to developing new and more useful products for the nation's household consumers, food, paper, textile, and other industries.

Construction of the Staley Research Center began in 1959. The structure consists of three wings. A four-story central wing houses 138 fully-equipped laboratory units, with modular

New Staley Research Center opened May 5 at Decatur, Ill., by A. E. Staley Manufacturing Co., is three-wing, 108,000-sq. ft. structure, dedicated to developing new and more useful corn, soybean, and chemical products for the nation's household consumers, food, paper, textile, chemical, and other industries

design for grouping units in work areas and flexibility in future arrangements.

A three-story south wing houses administrative offices and a technical library of some 10,000 bound volumes plus current scientific literature and information services drawing on central libraries. In the two-story north wing, a cafeteria seats 150, and an auditorium for 225 has on-stage provisions for laboratory demonstrations.

Air-conditioned throughout, the building has individual temperature controls in each room. Four "special climate" rooms are equipped to maintain specified temperature and humidity levels for research work with Staley product applications in the food, paper, textile, and other industries. A special room for "taste panel" testing in food research is typical of unusual facilities.

Other special facilities are provided for laboratory supplies, microscopy, spectroscopy, photography, glass blowing, equipment making, water distillation and distribution, shipping, sample storage, and care of glassware.

Advanced scientific equipment includes an electron microscope capable of $1^1/_2$ million diameter magnifications. Gas chromatography and infrared spectrophotometry are used to shortcut chemical analysis, providing data in an hour or a day that would take weeks or months, or perhaps be impractical to attempt by older means.

The exterior of the structure is light brick with aluminum framed windows, the interior partitioned with enameled steel panels, floored with vinyl plastic. Design is keyed to function, flexibility, economy, and maintenance.

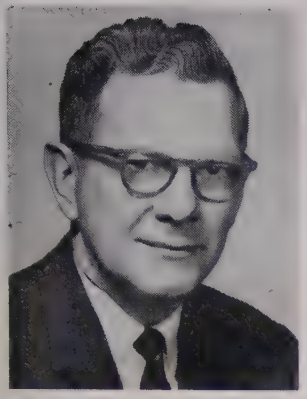
Extensive research facilities serving the paper, boxboard, corrugating, building materials, adhesives, and related industries are provided in the new Staley Research Center.

A special climate laboratory in the paper research section provides constant temperature and humidity control for experimental work in which atmospheric conditions are critical.

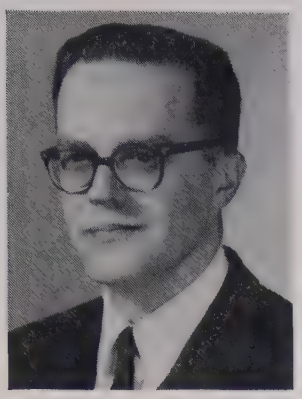
The largest piece of new equipment is a multipurpose pilot paper coating machine capable of drying a 10-lb. per-side coating on a 20-in. sheet at speeds up to 2000 f.p.m.

Other equipment includes a three-roll B. F. Perkins supercalender, equipped for continuous calendering; a precision trailing blade coater developed by Time and Life Laboratories for experimental applications; a Concora medium tester for wet end additives, and a Hinde and Dauch crush tester.

Auxiliary equipment includes a Vandercook proof press, Thwing-Albert tensile tester, MIT fold tester, Scott internal bond tester, Gardner 75° gloss meter; Brookfield eight-speed 100 r.p.m. Hercules Hi-Shear, and CIRF viscometers; IGT printability tester, and a Vanceometer unit.



Warren Stubblebine, Stowe-Woodward, Inc.



John G. Hendricks, Stowe-Woodward, Inc.

Stowe-Woodward, Inc.

The promotion of Warren Stubblebine to the position of sales manager-Roll Division has been announced by D. W. Stapleton, president of Stowe-Woodward, Inc.

Stowe-Woodward, currently celebrating its 75th anniversary, has plants in Newton, Mass.; Neenah, Wis., and Griffin, Ga., for the production of a variety of rubber covered rolls for use in the paper, textile, plastics, and other industries.

Stowe-Woodward, Inc. has announced the appointment of John G. Hendricks to the post of director of research and development. He will have responsibility for all developmental activities of the Ebonite Bowling Ball Div. in Newton, Mass., as well as for the Industrial Rubber Roll Div. in three Stowe-Woodward plants located in Newton, Mass.; Neenah, Wis., and Griffin, Ga.

Stickle Steam Specialties Co.

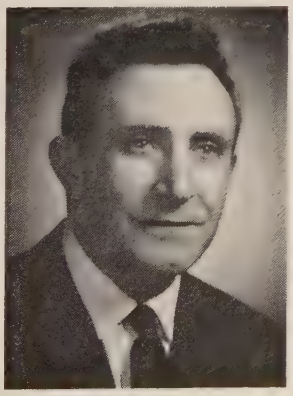
The latest drier drainage systems for paper and board machines are shown in new Bulletin 360-A, offered by Stickle Steam Specialties Co., 2215 Valley Ave., Indianapolis 18, Ind. Both two and three section systems are illustrated, along with micro adjustable orifices, pneumatic diaphragm motor control valves, condensate receivers and flash tanks, wet end temperature controllers, vacuum pumps, and control panels.

Stora Kopparberg Corp.

Harold Bialkowsky has been appointed assistant to the president of Stora Kopparberg Corp., New York, N. Y., and will be in charge of cellulose research and product development.

A native of Holyoke, Mass., Dr. Bialkowsky is a graduate of M.I.T. in electrochemical engineering. He received his M.S. and Ph.D. at The Institute of Paper Chemistry at Appleton, Wis. He started his career as a research chemical engineer for American Writing Paper Corp. of Holyoke, Mass. From 1933 to 1941 he was technical director of Gilbert Paper Co., Menasha, Wis. Since 1941 he has been with the pulp division of the Weyerhaeuser Timber Co., serving as director of research for the past 13 years.

Dr. Bialkowsky was a member of the TAPPI Executive Committee (1949–51), past-chairman of the Pacific Section, and has been active in the affairs of the Acid Pulping and Pulp Testing Committees of the Technical Association.



Harold Bialkowsky, Stora Kopparberg Corp.

Testing Machines, Inc.

PLY BOND STRENGTH OF PAPERBOARD

Now available from Testing Machines, Inc., 72 Jericho Turnpike, Mineola, N. Y., a data sheet illustrating and describing the ply bond tester. This testing machine was created to meet the need for additional physical testing of laminated products, gummed tape, and other packaging materials requiring high strength. The plybond test is a quick and easy method for attaching a numerical value to the internal bonding strength of paper and paperboard.

THE PATRA STACK THERMOMETER

This instrument gives a quick and accurate check on the temperature inside stacks of paper for the printer. Because paper is greatly affected by temperature changes (wavy edges, for example nearly always result from unwrapping a stack of cold paper in a warm room) it is necessary to compare the temperature in the stack with room temperature. This is easily done. Insert the PATRA stack thermometer through the wrapper and leave it there for 15 min. or until a steady temperature is reached. Compare the temperature of the stack and the temperature of the pressroom. When the two temperatures are the same, the wrapper can safely be removed.

This instrument provides the only known means of measuring the temperature inside the stack. Formerly, it has only been possible to make a guess—and a bad guess at that—because tests have shown that a 1-ft. cube of paper takes about 20 hr. to rise 30°F.

Thwing-Albert Instrument Co.

CURL SIZING TESTER

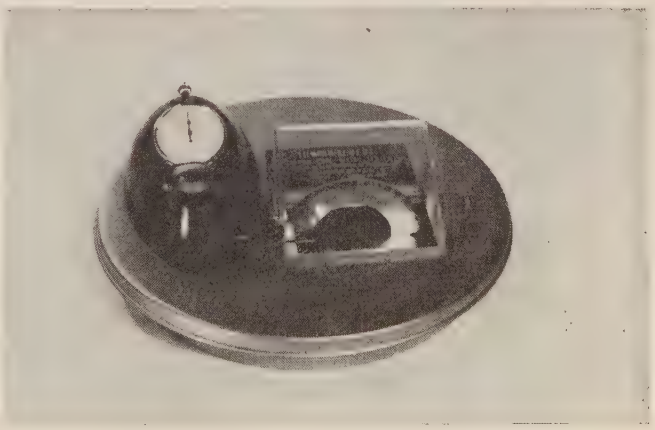
Thwing-Albert Instrument Co. announces the new Carson curl sizing tester for testing the degree of curl and sizing of papers up to ten thousandths of an inch in thickness.

The new design features an improved timing system which permits the operator to make more precise measurements. It also features a totally enclosed liquid container that helps eliminate spills.

Originally developed at the National Bureau of Standards the Carson curl sizing tester is built to conform to TAPPI Standard T 466 m-46.

The Carson curl sizing tester wets one side of a sheet of paper causing that side to expand and to curl. When the wetting liquid reaches the average center of the sheet the curl reverses. The time interval between the instant of wetting the sheet and the instant of reversal is a direct measurement of the time of penetration into the sheet, therefore a direct measurement of the degree of size.

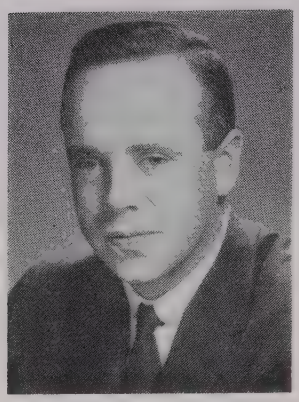
For more information write the Thwing-Albert Instrument Co., Penn St. & Pulaski Ave., Philadelphia 44, Pa.



Carson curl sizing tester

Jack M. Norlin, W. S. Tyler Co.

J. A. Weatherford, Virginia Chemicals & Smelting Co.



Stephen J. Elkins, H. Waterbury & Sons Co.

Miss Irene Gordon, Wallace & Tiernan, Inc.

W. S. Tyler Co.

Jack M. Norlin has been manager, Paper Mill Sales, by The W. S. Tyler Co., leading producer of paper mill wire cloth and screening machinery. Among the products for which Mr. Norlin will be responsible is Ty-Flex, the new stainless steel fourdrinier wire recently introduced by W. S. Tyler.

Valley Iron Works Corp.

Talbot Peterson and Willard C. Notbohm have been elected vice-president and Raymond A. Bennett, assistant sales manager of the Valley Iron Works Corp., a subsidiary of the Allis-Chalmers Mfg. Co.

Virginia Chemicals & Smelting Co.

It was recently announced that J. A. Weatherford had been promoted to the newly created position of director of sales for Viriginia Chemicals & Smelting Co. A. K. Scribner, president, stated that in his new position Mr. Weatherford will be responsible for all sales of the company including industrial chemicals, refrigeration and air conditioning products, aerosols and products sold overseas.

Wallace & Tiernan, Inc.

The Purchasing Agents Association of North Jersey today elected as its president the first woman member of the National Association of Purchasing Agents ever to hold the office of president of an affiliated association. She is Miss Irene Gordon, chief purchasing agent of Wallace & Tiernan, Inc., Belleville, N. J. She is responsible for purchasing in most divisions of W&T's diversified industrial organization. Among these are departments manufacturing chemical feeding and metering equipment, precision pressure instruments, pharmaceuticals, and cathodic protection systems for corrosion control.

H. Waterbury and Sons Co.

The appointment of Stephen J. Elkins as sales representative for Oriskany Waterbury Felts in the PenJerDel territory has been announced by Robert S. Greene, sales manager for H. Waterbury and Sons Co., Oriskany, N. Y. Prior to his new assignment, Elkins served for over two years as sales representative for the firm in New York State.

Weyerhaeuser Co.

The election of Howard W. Morgan, George H. Weyerhaeuser, and J. E. Nolan as executive vice-presidents of Weyerhaeuser Co. was announced today by Norton Clapp, president. The designation of three executive vice-presidents by the board of directors "is in recognition of the increasing responsibility they share for the progress and success of the company," Mr. Clapp said.

As the company's major operating executive in the pulp, paperboard, and container group, Mr. Morgan has direct responsibility for the manufacture and sale of products accounting for approximately half of the company's business. "Recent establishment of foreign manufacturing facilities emphasizes the world-wide nature of the operation of this group," the announcement stated.

George Weyerhaeuser has a similar responsibility for the operation of the company's wood products and timberland group. Recently reorganized to include the manufacture and distribution of all wood products, the operations of this group.

Curtis S. Walseth has been appointed associate research director of Weyerhaeuser Co.'s pulp and paperboard division, it was also announced.

General

U. S. Patent Office

The U. S. Patent Office has issued two pamphlets, "Answers to Questions Frequently Asked About Patents" and "Obtaining Information from Patents," which were developed and prepared for use by those who are faced with questions about patents, and, more specifically, where information from patents can be obtained.

"Obtaining Information From Patents"—Patent Office Classification and Search Services—March, 1960: Inventors, research people, or anyone interested in any field of development can now turn to this pamphlet, just published by the Patent Office, which contains information as to obtaining patents, searching, and the many services of the Patent Office.

"Answers to Questions Frequently Asked About Patents"—This Patent Office publication contains the answers to 40 questions about patents most frequently raised by inventors and businessmen.

Copies of these two pamphlets can be obtained from the nearest Field Office, U. S. Department of Commerce, or from the Office of Information Services, Patent Office, U. S. Department of Commerce, Washington 25, D. C.

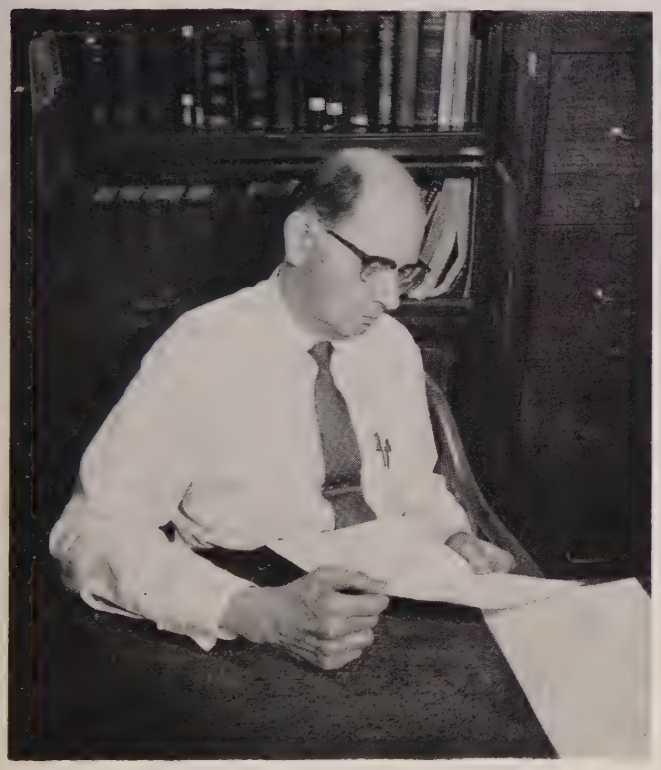
David L. Ladd of Chicago has taken over the duties as Commissioner of Patents of the U. S. Patent Office, Department of Commerce in Washington. As Commissioner of Patents, Mr. Ladd will make every effort to improve the effectiveness and services of the Patent Office. He shares with the inventor, business, and industry their interest in making known the importance of the patent system in the American Free Enterprise System.

The Patent Office celebrates this year the 125th Anniversary of the Act of 1836 (July 4). Since that date, nearly three million patents have been issued. The event is being celebrated during the entire year, with special programs in companies, schools, technical, and service organizations. Articles with special emphasis on patents and the Patent System are being encouraged.

U. S. Forest Products Laboratory

Earl R. Schafer, who has spent nearly 40 years at the U. S. Forest Products Laboratory conducting research on various aspects of pulp and paper production, retired May 6 and has accepted an appointment by the Food and Agriculture Organization of the United Nations to serve as technical adviser on pulp and paper research at the Forest Products Research Institute in the Philippines. He and Mrs. Schafer expect to leave about July 1, stopping in Rome, Italy, for FAO briefings on the way. They plan to remain in the Philippine Islands about a year.

One of the first assignments he received after his arrival at the Laboratory was to investigate the use of seed flax straw to produce a wide variety of papers. Although good samples of paper were turned out in the Laboratory, from a cost standpoint, the material could not compete with wood. Several years later, flax straw came into use for making cigarette papers when World War II caused a shortage of rags for high-grade papers. Today, most of the cigarette papers made in the United States utilize the fibers of seed flax straw.



Earl R. Schafer, U. S. Forest Products Laboratory

As head of the groundwood pulping section, Mr. Schafer played an important role in the development of various groundwood pulping methods. Under his direction, an experimental grinder was designed and built that produced groundwood pulp in the laboratory comparable to that turned out in commercial pulp mills. In making groundwood pulp, wood is fed into the grinder, where a stone wheel reduces it to fibers.

Mr. Schafer also conducted extensive studies of many foreign species and domestic hardwoods to evaluate their potential for the production of pulp and paper. As the result of this research, such little-used species as aspen and cottonwood, which had virtually no commercial value, gained new importance in the production of book and other printing papers.

More recently, experiments on pulping of Gewa, a wood native to the Southwest Pacific area, led to the establishment of a paper mill in East Pakistan.

Mr. Schafer is a member of the Technical Association of the Pulp and Paper Industry. For the past 17 years he has presided as chairman of the association's Fibrous Raw Materials Testing Committee, and is also a member of its Groundwood Pulping Committee.

Enzymes for Pulp and Paper Processes

A new process for the extraction and purification of certain hydrolytic enzymes may result in a substantial expansion of enzyme usage in the pulp and paper industry, according to a recent announcement by Western Biochemical Corp. of San Francisco. The process allows low-cost, volume production of amylase, protease and lipase enzymes having exceptional potency, purity and stability. In addition, they are said to be effective over a considerably wider range of pH and temperature as compared to other commercial enzymes.

The catalytic activity of the new enzymes is comparable to the magnitude of pure crystalline enzymes, which, combined with excellent stability, high purity, and low cost, is expected to extend enzyme processing techniques into a variety of new areas. Among the possibilities suggested by the manufacturers are the economical conversion of various fibers to quality grades of paper, recovery of cellulose from cotton linters, the extraction of cellulose from wood wastes and the deinking of wastepapers. In the conversion of starch to dextrins, for paper sizings, the new amylase enzyme allows a substantially faster rate of dextrin production with only a barely detectable trace of sugar formation.

The enzymes—amylase, protease, and lipase—are obtained by the culture of selected strains of *Bacillus subtilis*. The purification process, which is the subject of United States and Japanese patent applications, was developed over a period of 10 years by a Japanese biochemist, Dr. Toyosaku Minagawa, a pioneer in the industrial production of microbial enzymes, and his associate, Takashi Hamaishi, an engineering graduate of the University of Kansas and Waseda University. Exclusive manufacturing rights to the process are held by Pacific Laboratories, Inc., which has commenced limited production in a newly constructed plant in Honolulu. Western Biochemical Corp., 755 Sansome St., San Francisco 11, Calif., is exclusive sales agent.

Whether or not Dr. Minagawa's assumptions are valid must await extensive basic studies on the new products, which will be carried out under a research grant from the manufacturer. Meanwhile, the practical aspects of the process appear to represent a significant advance in enzyme technology.

Forest Research

A pioneering research group—the first of its kind in the U. S. Forest Service—has been set up to do basic research in forest mensuration, the science of measuring and predicting timber volume and growth. The project, which is national in scope, will be supervised by Lewis R. Grosenbaugh. Headquarters will be at the Pacific Southwest Forest and Range Experiment Station, Berkeley, Calif.

Karl F. Wenger has been named chief of forest management research at the Southern Forest Experiment Station, succeeding Mr. Grosenbaugh. In his new position, Dr. Wenger will coordinate and guide U. S. Forest Service management studies at field centers in seven Midsouthern states.

Hydrogen Peroxide Safety Data Sheets

Two safety data sheet supplements on hydrogen peroxide are now available from the Manufacturing Chemists' Association, Inc. Supplement SD-53-A details the physical properties and provides minimum engineering design recommendations for bulk storage facilities for hydrogen peroxide solutions not exceeding 52% concentration by weight. There is an increasing interest on the part of consumers in installing tank storage facilities at their plants for operating convenience in order to accommodate bulk purchases.

Supplement SD-53-B reveals the properties and recommended practices for packaging, handling, transportation, storage, and use of hydrogen peroxide solutions exceeding 52% concentration by weight.

Concentrations of hydrogen peroxide above 52%, generally known as high strength hydrogen peroxide, are commodities of increasing interest in commercial and military fields, especially the latter. Included in the information available in Supplement SD-53-B are important physical and chemical properties, uses, regulations, shipping containers and labels, bulk storage and handling equipment, safety precautions, and general information.

Copies may be obtained from the Manufacturing Chemists' Association, Inc., 1825 Connecticut Ave., N. W., Washington 9, D. C., at a cost of 30¢ each for Supplement A and 50¢ each for Supplement B.

Model Paper Machine

A model fourdrinier paper machine was originated by Marcia L. Matthews of Chagrin Falls, Ohio, with her father's help, for the Local Science Fair where she received one of the first prizes. This made her eligible to enter it at Kent State University in competition with all schools in Northeastern Ohio where she received a honorable mention award.

The machine was made with Masonite frames, different size wood doweling for driers, size press, couch roll, press roll, calender stack, winder, and rewinder. It has a real fourdrinier wire that actually turns by wrist power and all rollers

Marcia F. Mathews of Chagrin Falls, Ohio and her model fourdrinier machine

turn from friction of the paper. An adding machine tape, inside the head box, comes out the slice, across the wire, over the driers, through the stack, and winds up on the winder. The winder shaft extends through the frame and is operated by hand power.

The Hydrapulper was made from a tuna fish can with a gear for the breaker knife. The beater was made from a sardine can with a center island installed, the cardboard roll actually turns.

A Dirtex cleaner unit was recently added just before it was put on display at the Ohio Section of TAPPI meeting in March.

The entire unit is 6 in. high, 6 in. wide and 48 in. long.

Marcia's father, R. C. Matthews, is employed by the Chase Bag Co.

Nicaragua

Total exports from Nicaragua may increase by approximately 50% within 20 years as the result of the decision to set aside 1 million acres for a pine forest in the northeast of the country, according to Bruce W. Taylor of the Food and Agriculture Organization (FAO), who has just completed a five-year assignment in that Central American Republic.

The project could lead to the establishment of a large paper and pulp industry in the area which would become a valuable part of the Nicaraguan economy.

Spruce Bark

Spruce bark, which up to now has been a waste product of the pulp and paper industry, shows promise of becoming a useful source of tanning materials.

Work presently being conducted at Ontario Research Foundation, Toronto, has shown that an extract from spruce bark can be used to replace the conventional vegetable tanning agents, such as wattle or quebracho, or mixed with them to produce better leathers. The research has been under the direction of W. C. Henry, director of the Foundation's Department of Biochemistry, and has been supported in part by the Defence Research Board of the Department of National Defence (Canada).

UN National Accounts Yearbook

The real gross product of almost every country of the world increased substantially during the period 1950–59, according to the United Nations "Yearbook of National Accounts Statistics" for 1960. This fourth issue of the Yearbook contains national accounts estimates for 95 countries and territories.

The present issue of the Yearbook reflects the growth in both the number and quality of official national accounts which are now prepared on a regular basis by national statistical services. Detailed estimates, where available, are shown in separate country chapters for each of the following subjects (1953–59): expenditure on gross national product; industrial origin of gross domestic product; distribution of the national income; finance of gross domestic capital formation; composition of gross domestic capital formation by type of capital good, by industrial use and by type of purchaser; receipts and expenditures of households and private nonprofit institutions; composition of private consumption expenditure; general government revenue and expenditure; and external transactions.

To facilitate country comparisons, the estimates for most countries are set out in standard tables to conform to international definitions in this field. The tables are documented with explanatory notes and source information.

A new section of the 1960 Yearbook is devoted to five international tables. Table I contains time series, generally for the period 1950–59, of the principal aggregates, such as gross national product, gross domestic product, and national income and their interrelationships for 92 countries and territories.

The remaining four tables are analytical ones. Table II shows rates of growth of total and per capital real gross domestic product and its components for the period 1950–59. The last three tables show, for the years 1950, 1953, and 1959, the relative significance of these components in the gross domestic product, the relative shares in national income of different types of income and the relative importance of the different sources of finance of gross domestic capital formation and of saving.

The "Yearbook of National Accounts Statistics" 1960, 308 pages, is obtainable from United Nations Sales Agents throughout the world. In the United States it may be obtained from the Sales Section, Publishing Service, United Nations, New York. The price is $3.50 per copy.

TAPPI DIVISIONS AND COMMITTEES

Authorized Committee Assignments

The following new committee assignments were made during May, 1961. The total number of assignments now active in the 63 TAPPI technical committees is about 360. An identifying number is given by TAPPI headquarters to each work assignment made by a committee chairman and approved by the appropriate division chairman. Assignment numbers should be requested for *all* activities of technical committees. A separate series of numbers is reserved for each of the technical divisions.

Assignment no.	*Committee*	*Title and objective*	*Committeeman in charge of assignment*
		COATING AND GRAPHIC ARTS DIVISION	
1011	Coating	"13th Coating Conference (1962)" arrange and hold a coating conference at the Netherlands Hilton Hotel in Cincinnati, Ohio, May 14–16, 1962.	C. G. Whelpton
1012	Coating	"14th Coating Conference (1963)" arrange and hold a coating conference at the Concord Hotel, Kiamesha Lake, New York, May 19–22, 1963.	
1013	Coating	"15th Coating Conference (1964)" arrange and hold a coating conference in New Orleans, La., in May, 1964. Exact date and location to be decided.	
1014	Coating	"16th Coating Conference (1965)" arrange and hold a coating conference on the West Coast in May, 1965. Exact location and time to be decided upon later.	
1015	Coating	"Survey of Pilot Coating Equipment" to prepare and publish a list or directory of all pilot coating equipment in the United States and Canada. It is intended to include in the listing all web coating equipment and auxiliaries that are used for research, development, and sales service work. Auxiliaries would include driers and calender.	M. V. Merchant
		ENGINEERING DIVISION	
4020	Process Instrumentation	"1963 TAPPI-ISA Instrumentation Symposium" jointly sponsored conference. (Under consideration.)	
4021	Mechanical Engineering	"The Design and Mechanical Application of 'Formex' Forming Fabric to Paper Machine" to disseminate knowledge on alterations to a fourdrinier required to run the new plastic wires.	C. E. Hill
4022	Mechanical Engineering	"Vacuum Pipe Velocities" establish a recommended range of velocities for vacuum piping installations.	A. Jordan
4023	Mechanical Engineering	"Vacuum Measurement" to standardize the method and locations for measuring vacuum in suction rolls and suction boxes.	B. L. Merris
4024	Mechanical Engineering	"Vacuum Pump Selection Factors" to establish a basis to evaluate the vacuum pump requirements of paper machines.	F. A. Taska
4025	Economics	"Potential Cost Reduction Areas of Pulp and Paper Manufacturing Processes" to define those areas of the paper manufacturing process which offer the greatest opportunity for cost reduction.	
4026	Maintenance Engineering	"Performance of Rubber Covering on Paper Machine Rolls" to find those areas in which problems exist, and to find the scope and objectives of projects which might be undertaken to arrive at a technical evaluation.	L. L. Smith
4027	Mechanical Engineering	"Application of the Roll-less Flo-Vac on a Fourdrinier Machine" to disseminate knowledge on the constructional features of the roll-less Flo-Vac and alterations to a fourdrinier required for its installation.	C. E. Hill
4028	Electrical Engineering	"Automating a Roll Grinder" a case history of the problems involved, and the methods used to automate a roll grinder to grind crowned machine rolls.	R. J. Minges
4029	Electrical Engineering	"Capacitance Effect on A.C. Control Circuits" point out the capacitance effect on a.c. control circuits, and set up a guide as to limitations in the use thereof.	R. J. Minges
4030	Electrical Engineering	"Current Nema Standards for A.C. and D.C. Rotating Machines" to provide a source of information for the pulp and paper industry to enable the industry to be brought up to date on the latest Nema standards.	R. J. Minges
4031	Electrical Engineering	"Pros and Cons of Inherently Protected Motors" to evaluate the various methods of inherent protection, and to point out areas of proper and improper application.	R. J. Minges
		TESTING DIVISION	
8018	Chemical Methods	"Revision of T 405 Paraffin in Paper" revision.	P. E. Hardy
8019	Chemical Methods	"Determination of Metals in Paper" write up methods for the determination of Ca, Fe, Cu, Mn, and Mg after *dry ashing*, and Hg, Pb, Sn, Zn, and Ni after wet ashing.	K. A. Kuiken
8020	Chemical Methods	"Determination of Melamine Resin in Paper" test method.	B. W. Forshee
8021	Paper Testing and Physical Methods	"Softness of Sanitary Tissue" prepare a test method.	J. E. Ray

Coating and Graphic Arts Division

Coating Committee

The meeting was opened at 10:00 a.m. on May 10, 1961, at the Hotel Statler, Buffalo, N. Y., by Chairman C. G. Landes, who, after welcoming Coating Committee members and guests, called on Harold Annis, president of TAPPI, for his comments.

Mr. Annis praised the Coating Committee for its many successful conferences, including the present 1961 meeting, as well as for activities in the project and monograph areas. He expressed his confidence in the present committee, its activities, officers, and method of operation. He summarized his remarks by encouraging the committee to keep up the good work.

Minutes—R. W. Hagemeyer

The minutes of the Feb. 20, 1961, meeting were mailed to all committee members. The minutes were approved as submitted.

Membership—R. W. Hagemeyer

The requirements for membership on the Coating Committee were reviewed. Copies of the present membership list were mailed to all Coating Committee members. Additional copies were distributed during the meeting. Any errors or omissions in this list should be called to the attention of the secretary. A revised list will be issued by Sept. 1, 1961.

Monographs—R. W. Hagemeyer

Assignment No. 303: Paper Coating Additives—H. R. Hall. At the recent meeting, May 9, 1961, the authors thought that they could complete their chapters by September 1. Allowing time for reviewing and correcting, the monograph should be ready for publication by Feb. 1, 1962.

The chapter on Dispersants by Messrs. Thompson and Robinson is complete. The following chapters are nearing completion:

Viscosity Modifiers	R. A. Diehm
Insolubilizers	D. D. Ritson M. E. Stonebraker D. S. Greif
Preservatives	J. R. Nelson R. F. DeLong
Plasticizers and Waxes	R. B. Porter G. S. McKnight C. G. Landes
Synthetic Water-Soluble Adhesives	P. W. Plante G. P. Colgan

Authors of the remaining chapters, Defoamers, Dyes, and Pigments, will be contacted.

Assignment No. 796: Pigment Coating of Paper and Board—G. L. Booth. This is a revision of Monographs 8 and 11. The present status is as follows:

Part I—Coating Methods. Six chapters are completed, 11 chapters are in progress, two additional authors are needed.
Part II—Drying. Completed.
Part III—Color Preparation. Four chapters are completed, four chapters are in progress.

Target date for completion of all chapters is Sept. 1, 1961. Following this, the Steering Committee will review and edit the manuscripts. It is hoped that this work can be completed and ready for submission to TAPPI Headquarters by Feb. 1, 1962.

Projects—F. Kaulakis

Assignment No. 910: Adhesive Studies—M. L. Cushing. At its February, 1961, meeting, this subcommittee decided to conduct a literature survey as a preliminary to any Research Project proposals on paper coating adhesives. At the meeting held on May 9, Bayard Carlson volunteered to draft a proposal covering a literature survey on adhesive distribution. A. C. Eames indicated that Joseph Bergomi, a graduate student at The Institute of Paper Chemistry, is studying adhesive redistribution for his doctoral thesis. Mr. Carlson is planning to visit Mr. Bergomi and will see what literature sources he has developed. Mr. Carlson is also undertaking some studies in his own laboratories to investigate this phenomenon.

The following new members were added to the subcommittee, bringing the total membership to 23:

C. L. Garey, The Institute of Paper Chemistry, Appleton, Wis.
Richard C. Brown, U. S. Envelope Co., Metuchen, N. J.
Professor J. J. Bikerman, Massachusetts Institute of Technology, Boston, Mass.
Arnold C. Eames, S. D. Warren Co., Cumberland Mills, Me.

Assignment No. 911: New Projects—General—J. Frankevicz. This subcommittee recommends that a questionnaire be circulated to determine the desirability of preparing a monograph on calendaring and finishing of coated paper which should include all commercial processes such as cast coating, water box finishing, and similar procedures. (By a show of hands, the Coating Committee expressed interest in this proposal.)

During the coming year this subcommittee will:

1. Investigate work already completed at The Institute of Paper Chemistry in an effort to redefine and limit the previous proposal to study "The Affect of Pressure in the Coating Unit on the Rheology, Penetration, and Other Properties of Coating Colors."

2. Send out 25 to 30 requests for ideas for new projects from selected members of this industry.

3. Develop a simple questionnaire for a wider distribution of idea requests.

Action on a suggestion for a bibliography on ink absorption was postponed in view of the current research project on ink receptivity. It is hoped that this project report will have a sufficiently adequate bibliography to satisfy any such need.

Chairman C. G. Landes, with the approval of the Coating Committee, appointed M. V. Merchant to head up a subcommittee to draw up a list of all pilot coating equipment in the United States and Canada.

Assignment No. 912: Pigments Studies—W. R. Willets. The subcommittee on pigment studies met at 2:00 p.m., May 9, 1961, with C. G. Albert presiding in the absence of Chairman W. R. Willets. Total attendance at the meeting was 14, including five subcommittee members.

The meeting had as its principal purpose a review of Proposal No. 61-631C from Armour Research Foundation dealing with "Prediction of Brightness and Opacity of Coated Paper." The consensus of the subcommittee members present was that the proposal, in its present form, could not be wholeheartedly recommended for TAPPI consideration; although there was a great deal of merit in some of the planned studies. It was concluded by the subcommittee members present that the Armour research proposal should be recast with some shift of emphasis to the more fundamental aspects of the study and then re-examined in terms of its new scope and objective. It is anticipated that the program might be retitled "Fundamental Study of the Optical Properties of Pigment Dispersions."

The purpose of the contemplated study would be to acquire basic knowledge as to the relationships of scattering and absorption coefficients with variables such as void volume, pore size, etc., for pigments of differing particle size, particle shape, refractive index, etc. The project as presently conceived would not be directed toward objectives of an immediately practical nature. It can be anticipated, however, that contributions to the basic understanding of the type of pigment relations discussed should ultimately lead to more

efficient utilization of pigments and/or the development of superior pigment materials.

The subcommittee confirmed the conclusion reached at its February 21 meeting that any worth-while research program contemplated should be supported on a financial scale adequate to allow a reasonable expectancy of accomplishing the stated objectives. Should a proposal come from the present subcommittee discussions which might meet all other criteria but might entail expenditures greater than TAPPI as an organization can reasonably sustain, the subcommittee indicated willingness to attempt supplementary financing in order to assure that such a program could be undertaken.

In the brief discussion that followed, some rather pointed questions were raised regarding the merits of the proposal, with opinions expressed both pro and con. Mr. Trelfa commented that the proposal should be judged strictly on its merit, and that it should not be shelved because of magnitude or cost. If the project has sufficient importance and is wholeheartedly endorsed by the Coating Committee, it is his feeling that the details of financing, etc., can be worked out.

Assignment No. 913: Factors Affecting Coat Weight—Air Knife Coater—R. J. Jacobs. Due to inability to develop interest and contributions to this project, despite several comprehensive attempts, it is recommended that this project be dropped. A motion to accept this report and drop Assignment No. 913 was approved.

Assignment No. 1010: Graduate Thesis Subjects—C. C. Kesler. This is a new assignment and the subcommittee is at present in the process of being organized.

Technical Information Sheets—R. W. Martinek

Assignment No. 1000: L. E. Georgevits. The name of the committee will be changed from the Coating Data Sheet Committee to the Coating Technical Information Committee. In the future, TAPPI will issue technical information sheets rather than data sheets.

As of April 1, Al Landers has joined the TAPPI staff; and he will be in charge of preparing new technical information sheets and revising the old data sheets.

Information on the physical properties of starch, clay, and titanium dioxide has been submitted to TAPPI, but no action has been taken pending the arrival of Mr. Landers. By the February, 1962, TAPPI meeting, these technical information sheets should be ready.

The subcommittee on pigment technical information, headed by Wade Claxton of Minerals & Chemicals Philipp Corp., has made good progress in preparing a list of the important physical properties of clay, calcium carbonate, and titanium dioxide. The test methods for determining these properties are now being reviewed. Any pigment supplier not on this subcommittee should contact Mr. Claxton.

The subcommittee on adhesives technical information, headed by C. W. Cairns of Dow Chemical Co., is preparing a list of latices used in paper coating, together with their trade names and physical properties. The physical properties to be listed have been decided upon, and the test methods for determining these properties are presently being reviewed. The subcommittee is planning to meet at the TAPPI Plastics Conference this fall, and they hope to have some information ready for publication at the next (1962) Coating Conference.

Our Engineering Technical Information Subcommittee, headed by R. Zabe of Charles T. Main Co., has still been unable to obtain any cooperation from the coating mills. We will attempt to work closer with the Engineering Committee in order to obtain the desired information.

Liaison—R. W. Martinek

Assignment No. 1001: RC Methods Committee—R. I. Bashford. This being a new assignment, there is no progress report. Meetings of the Routine Control Methods group will be attended and any information of interest to the Coating Committee will be reported.

Assignment No. 1002: ASTM D 25—J. F. Voit. A meeting of ASTM D 25 Committee was held in New York following the National TAPPI, February meeting (1961). The committee will release a standard method for measuring coating viscosity in the near future. The method initiated by Mr. Georgevits has been approved by the committee and submitted to ASTM for final approval and release. The TAPPI Coating Committee will be informed of the number and nature of the method as soon as final ASTM approval is received.

L. E. Georgevits resigned as ASTM D 25 Committee Secretary, and the activities have been delayed until another secretary can be appointed. This should take place shortly.

Assignment No. 1007: Transfer and Penetration Aspects of Ink Receptivity—H. M. Hughson. The above subcommittee was appointed by the Graphic Arts Committee under the chairmanship of Dr. W. C. Walker to initiate the ink receptivity research project. Lehigh University was chosen to carry out and report on the experimental phases of the project, and their initial proposal was issued in July, 1958.

The subcommittee now includes in its membership H. J. Connell (who is also the new chairman of the Graphic Arts Committee), J. G. Curado and its chairman, Dr. W. C. Walker, as well as the writer. Its second meeting of the year was held at Lehigh on March 21 and March 22, the purpose being to review its aims and to ascertain, from the research personnel at the University, the present state of progress of the project on which they have now spent roughly $18,000.

I have found that the subcommittee has been working hard on this worth-while project; but, in its present state, the findings cannot be of too much immediate, practical use to coated paper manufacturers. The work has been primarily concerned with exploring the three parameters of ink transfer developed roughly seven years ago at Lehigh. These parameters are b, the thickness in microns of the ink film immobilized as the paper contacts the plate; f, the percentage of the remaining free ink film that is split off to remain on the sheet; and k, a measure of surface smoothness of the paper. The work has been carried out with three different types of inks and up to four printing pressures, three printing speeds, and four different types of paper (two coated, two uncoated) chosen somewhat arbitrarily to represent extremes of ink receptivity and holdout. A very large number of tests have been carried out, since several levels of ink film thickness must be applied for each of the different operating conditions. The main attempt has been to find some pattern of correlation of the three main parameters with the various printing conditions. The program has covered more territory than many of their previous investigations at Lehigh and has uncovered some anomalies of behavior that were previously unsuspected.

Unfortunately, although they have tested the paper with a fairly wide variety of standard printability tests, there has been little opportunity to tie in the tested properties with the variations in the ink transfer constants. They have done some gloss measurements of the printed papers but these data are not yet complete.

We have asked the Appropriation Committee to assign enough funds to complete the project in roughly six months; but, this should consist largely of finishing the work of establishing the levels of the three parameters with the third ink completing the paper tests, running some more elaborate programs on the computor, and writing a definitive final report. The subcommittee chairman will be retiring his post after this final report is received, and we do not contemplate going any further with other papers. It is hoped that the final report will show where to concentrate the ink transfer and receptivity measurements and which of them are most useful in defining differences between papers. It would then become the task of another subcommittee, possibly from the Coating Committee, to generate a subsequent project for Lehigh, supplying them with papers which represent planned

differences in formulation of adhesive and pigment, or perhaps representing known commercial defects. This, of course, would take close cooperation with coated paper manufacturers who could supply the required sheets from pilot coaters or commercial operations.

It is recommended that upon receipt of the final report Mr. Frankevicz's committee on New Projects study the findings with the aim of initiating a new project to continue the valuable work that Lehigh is doing. The recommended attack would be to choose a greater variety of coated paper samples, with more elaborate printability tests done on the candidate samples. These further tests could be done by several mill laboratories and would include various proof press comparisons to establish a full spectrum of smoothness, receptivity (ability to remove ink from the plate), and absorbency (ability to draw ink vehicle into the body of the sheet—the inverse property being holdout). The receptivity and smoothness properties of the samples chosen could then be explored by the Lehigh methods using the minimum significant number of printings and whichever of the techniques and parameters that have been pointed out in the final report as being most rewarding.

Future Conferences—C. G. Whelpton

Assignment No. 881: 1962 Conference—C. G. Whelpton. The Thirteenth Coating Conference will be held at the Netherlands Hilton Hotel, Cincinnati, Ohio, May 14–16, 1962. The Conference Committee is made up of C. G. Whelpton, general chairman; W. E. Welliver, technical program chairman; J. E. Chinn, publicity chairman; and W. H. Dietz, local arrangements chairman. The proposed theme for this conference is "Challenges of the Sixties." Anyone wishing to offer a paper should contact Mr. Welliver.

1963 Conference—Kiamesha Lake, N. Y.—Concord Hotel
1964 Conference—New Orleans, La.

Assignment No. 1003—Coating Committee Organization and Operational Review: J. J. Thomas

Dr. F. H. Frost submitted the following for Mr. Thomas:

Progress Report on Assignment No. 1003 on Committee Organization and Operational Review.

Objective: Insure continued efficiency of administration and conduct of Committee Affairs.

Members of Subcommittee: J. P. Casey; R. T. Trelfa; J. E. Wilber; A. J. Winchester; J. T. Loomer (Advisory); J. J. Thomas, Chairman.

Actions to Date:

1. Canvass of opinions via correspondence.

2. Full subcommittee deliberated in New York City on March 27, 1961, and came up with several recommendations that are delineated below.

3. Verbal report presented by J. J. Thomas and A. J. Winchester at Buffalo, April 10, 1961, to Coating Council meeting.

Recommendations to Chairman Landes: In general, the present structure and "modus operandi" of the Coating Committee and its administration via the Coating Council are sound and should be continued. This committee submits the following as potential means of increasing efficiency and making our operations more democratic:

1. Reinstitute the Advisory Committee in order to benefit from the experiences and sagacity of the senior members of the Coating Committee, especially in policy matters.

2. Consider using a nominations committee to select new members of Coating Council.

3. With approval of TAPPI president and Executive Committee, elect Coating Council chairman and vice-chairman from within Coating Council, thus doing away with automatic succession within Council. New members of Council, increased to six, would be elected via the following scheme:

1. February, 1962—Select one new member for 2-year term. Promote vice-chairman to chairman. Select new vice-chairman from Council.
2. February, 1963 and February, 1964—Select two new members for 2-year terms. Promote vice-chairman to chairman. Select new vice-chairman from Council.
3. February, 1965, et seq. —Select two new members for 2-year terms. Promote vice-chairman to chairman.
—Select new vice-chairman from outgoing councillors or committee at large.

4. Chairmanship of the Coating Conference might be open to any member of the Coating Committee rather than an automatic assignment of the Junior Council member.

5. More projects should be instituted, more job assignments be given to Coating Committee members, more subcommittees created to execute work assignments, use Advisory Committee to select worth-while projects.

6. Each one should be more self critical in his TAPPI job, whether the unit be the individual, a subcommittee, the Council, or the Coating Committee itself. Only in this way can progress be made.

Future. After deliberations by the Coating Council and by individual members of the Coating Committee on the above suggestions, if further action is required on this Assignment No. 1003, your subcommittee will be happy to act.

Sponsored Research Projects—C. G. Landes

Assignment No. 536: Flow Properties of Coating Colors—G. A. Hemstock. Since the TAPPI meetings in February, a report has been distributed to members of the Coating Committee on the work which has been done during the past two years at the University of Maine. That report dealt with the penetration behavior of clay–Karo sirup–water systems and clearly established the importance of vehicle viscosity in controlling penetration. Work is continuing on studies of clay–starch–water systems, but the work has not yet progressed far enough to justify any report at this time.

The present TAPPI appropriation expires as of July 1 of this year. On the basis of the approval of the members of the Coating Committee at the February meeting, a new request for funds was submitted to the TAPPI Research Appropriation Committee in April. This would cover activities of the project up to July 1, 1962. Approval of this appropriation request has not yet been received.

In conclusion, Chairman Landes asked R. T. Trelfa, chairman of the Coating and Graphic Arts Division for his comments on the Coating Committee and its activities. Mr. Trelfa complimented the group on its accomplishments and urged a continuing effort to promote the Coating Committee and its objectives. Further, he cautioned against limiting the goals of the various projects because of shortsightedness resulting from too much emphasis on the practical aspects of the work. Mr. Trelfa asked the committee to consider broad rather than narrow concepts and to look at basic fundamental causes before considering practical effects. This basic approach should be followed in all Coating Committee activities to insure the sound forward planning necessary for continued progress and success.

R. W. Hagemeyer, *Secretary*

Converting and Consuming Division

Wet Strength and Interfiber Bonding Committee

The agenda and decisions taken at the annual national meeting of the Wet Strength and Interfiber Bonding Committee held Feb. 21, 1961, in New York, N. Y., were as follows:

Committee Reorganization. C. S. Maxwell assumed the chairmanship of the committee following the moving up of Ken Britt to the Converting and Consumer Division vice-chairmanship. M. L. Cushing was appointed to the position of secretary.

Joint Session with Plastics Committee. It was agreed that the Wet Strength and Interfiber Bonding Committee would provide a series of papers as part of the Oct. 9–11, 1961, Plastics-Paper Conference at French Lick, Ind.

A review of Research Proposals or suggestions for areas of research under the jurisdiction of the committee was conducted. It was decided to proceed with write-up for submission before April 1 of a proposal from the State College of Forestry at Syracuse University on the mechanism of wet-strength development with polyethylene-imine, and, secondly, to refine the areas of research proposal for future consideration on location, identification, and effects of natural (and synthetic) resins on or in papermaking fibers.

A subcommittee comprising A. C. Schmalz, chairman, D. S. Most, J. W. Swanson, and H. L. Winslow was appointed to work on the polyethylene-imine project write-up.

After having decided that the polyethylene-imine project should have first priority a voting to select the second priority project, which was the above-mentioned resin location study, it was found that the third place choice would go to the suggested work in the area of retention of polysaccharide wet-end additives, fourth place to proposed studies on rheology of wet-strength papers in various solvents. It was evident that little interest remained concerning a suggestion for work on mechanism of filler retention, with some feeling that any work here should belong under some other committee's jurisdiction.

Program for National TAPPI 1962 Meeting. It was decided that tentatively the committee would solicit papers and plan to sponsor a session at the 1962 annual TAPPI Meeting.

Revision of Wet Strength Monograph. While no decision was taken there was a discussion and general agreement that it would be worth while to consider undertaking a revision of TAPPI Monograph Series No. 13, Wet Strength in Paper and Paperboard.

New Members. The following are new members of the committee: Alex Pociluyko, Scott Paper Co.; Grant K. Rauscher, International Paper Co.; and Richard B. Valley, Eastman Kodak, Rochester, N. Y.

M. L. Cushing, *Secretary*

Corrugated Containers Division

Raw Materials Committee—Medium and Liner Subcommittee

The meeting convened at 9:30 a.m., Feb. 20, 1961, in New York.

H. Nelson—review and evaluation of butyl carbitol and water drop test results versus pin pull test results. No report.

Preliminary studies of effects of wet streaks. This project was done by John Hart and Bert Jones. There was a general discussion of the effects of wet streaks and it was decided that there were enough data already. Further investigation would not be fruitful therefore, Mr. Hart will send forms to the committee members for their standards and recommendations on wet streak allowances. He will then summarize the maximum recommended variations in moisture.

Suggestion for New Projects

G. H. McGregor—suggested standardizing test methods for Concora. Apparently, there are enough variations in methods to materially affect test results. Mr. Robson will check with TAPPI to see if a testing committee should take over this project.

F. Albert—brought up the problem of cracking scores with lightweight liners on A-flute board. This has become a problem with the advent of stiffer medium. Suggested that this might be solved by changes in scoring profile or that perhaps the mills might be able to increase the strength of the liners without adversely affecting their cost.

H. Adickes—suggested the following list of variables affecting performance of liner and medium which could be used as a source of project ideas:

Medium

Types: straw, northern semichem, southern semichem, and bogus.
General: basis weight, caliper, finish, moisture, tensile, stretch, concora, stiffness, shear, coefficient of friction, and abrasiveness.
Furnish: Hardwood semichem—Sometimes difficult to corrugate, Poor gluing glue penetration, bonding, and forming.
Bogus: foreign particles, presence of grit, harsh on corrugating rolls, presence of tar (staining through linear, sticking to rolls, shrinkage).
High humidity strength (Treated or untreated): Resin present—sometimes forming and gluing problem. No-resin—necessary to use 34 to 36 lb. for HH strength equal to 26-lb. treated.

Liner

basis weight, caliper, mullen, strength, finish, moisture, stiffness, sizing, pH Factor, coefficient of friction, and color.

A. Magnuson—Potlatch has used the Vanceometer in a glueability test and found good correlation. He offered to furnish the details to the committee members and those who have vanceometers will cooperate in the project.

Messrs. Magnuson, Hamilton, and Robson, will do a preliminary check on linerboard and corrugating medium before a large-scale project is started.

J. Challas—The higher concora medium seems to have a higher coefficient of friction which influences runability. Mr. Challas said; he would measure coefficiency of frictions if we would send samples of medium which ran poorly and some that ran well.

Pulp Manufacture Division

Sulfite Pulping Committee

The meeting was called to order at 2:10 p.m. Feb. 21, 1961, in New York, N. Y., by P. E. Trout, Waldorf Paper Products, St. Paul, Minn., chairman.

Minutes of Previous Meeting. The minutes of the meeting held in Portland, Ore., on Aug. 22, 1961, were approved as written.

Chairman's Report. The committee chairman reported that the present membership of the committee stands at 24, that there are no projects currently active, that the half-day session sponsored by the Sulfite Pulping Committee at the Alkaline Pulping Committee Meeting in Portland, Ore., was well received and attended, as were the current sessions at the TAPPI Annual Meeting. The next committee participation will be a half-day technical session at the forthcoming Alkaline Pulping Conference in Houston, Tex.

Program Chairman's Report. E. D. Cann reported that emphasis at the TAPPI Annual Meeting was being placed on acid sulfite pulping, whereas our participation in the Alkaline Pulping Conference would attempt to emphasize semichemical sulfite pulping. He stated that good progress was being made in securing papers for the Houston session. Although there is some conflict from the Technical Section, C.P.P.A. meeting at Saranac Lake, our program should be completed by July.

Mr. Cann also requested that a program chairman for 1962 be appointed to work with him for the balance of the year to learn the technique and insure a smooth transition in program chairmanship.

New Business. There being no old business, the group

proceeded to the election of officers for the current year. A letter of resignation from S. R. Parsons, secretary, was read and regretfully accepted. Mr. Trout was nominated as candidate for chairman and J. S. Hart as vice-chairman if his other duties would permit (he has since accepted the job as vice-chairman). Several suggestions were made for secretary, with the chairman being instructed to contact these men about serving as secretary.

The monograph on chemical recovery being compiled by the Alkaline Pulping Committee was discussed. Mr. Hart moved, Mr. Parsons seconding, that the Sulfite Pulping Committee offer full support and assistance to the Alkaline Pulping Committee in preparation of the monograph.

Next Meeting. The next meeting of the Sulfite Pulping Committee will be held during the Alkaline Pulping Conference in Houston, Tex., on Nov. 1 or 2, 1961.

There being no further business, the meeting was adjourned at 3:45 p.m.

P. E. Trout, *Secretary, pro tem*

Testing Division

Routine Control Methods Committee

The meeting was called to order in the East Ballroom Parlor of the Hotel Commodore, New York City at 11:30 a.m., Feb. 20, 1961, by Chairman L. J. Slentz.

Chairman Slentz opened the meeting by giving a brief review of the committee's activities during 1960. He outlined the following accomplishments: (1) the publication and distribution by TAPPI Headquarters of a loose-leaf binder for R. C. Methods, (2) number of R. C. Methods published—17, (3) number ready for publication in 1961–9, (4) number of R. C. Methods dropped—6, (5) methods to be published as addendums to existing R. C. Methods—2, (6) methods currently in process for publication—17.

He then distributed to each member a list of the 17 methods in process plus 28 additional methods submitted for review and processing in 1961. He then solicited the cooperation of the members present to accept assignments of the various methods for their review and editing. Assignments were made as follows:

Published in Tappi	*R. C. no.*	*Title*
January, 1961	292	Determination of Specific Gravity of Liquid Resins (Hydrometer Method)
January, 1961	293	Measurement of pH of Liquid Resin Syrups
January, 1961	294	Measurement of pH of Liquid Resin Syrups at pH 11 or Higher
March, 1961	295	Degree of Sizing in Paper
March, 1961	296	Torsion Tearing Resistance of Paper
March, 1961	297	Wax Transfer of Paper
May, 1961	298	Benzene Solubility of Petroleum
May, 1961	299	Hardness Index of Pulp (Mullen Test Method)

Committee Assignment No. 8008

Ref. no.	*Title of method*	*Assignee*
60-7	Sodium in Kraft Lime Sludge (Flame Photometer Method)	C. L. Hess
60-10	Sodium Salt Content of Kraft Pulp (Flame Photometer Method)	C. L. Hess
60-13	Efficiency Test for Antifoams	C. L. Hess
60-15	Porosity-Smoothness Softness of Paper (Gurley)	M. A. Burnston
60-16	Porosity of Paper (Sheffield)	M. A. Burnston
60-25	Stiffness in Paper and Board (Gurley)	L. J. Slentz
60-30	pH Value of Clay	C. L. Hess and R. DeVose
60-31	Grit and/or Screen Residue in Clay	C. L. Hess and J. R. DeVose
60-32	Viscosity of Coating Clay Slurry	C. L. Hess and J. R. DeVose
60-33	Sedimentation Test of Coating Clay	C. L. Hess and J. R. DeVose
60-35	CPS Tests for Coating Clays	C. L. Hess and J. R. DeVose
60-38	Total Absorption Test for Bibulous Papers	P. J. Hakim
60-39	Bendtsen Method for Smoothness and Porosity	Ready for publication
60-40	Hengar Method for Organic Nitrogen	J. P. Carey
60-41	Brightness of Clay	R. S. Hunter
60-43	Shear Strength of Water Resistant Adhesives	J. P. Carey
61-1	Determining the Order of Chemical Reactions	
61-2	Crush Test	
61-3	Activity Test for Black Liquor	C. L. Hess
61-4	Rapid Determination of Wax in Paper	D. R. Cushman
61-5	Oil Test on Patent Board	
61-6	Drying Speed Test	
61-7	Iron in Pulp	
61-8	Water Run Off Test: Paper Asphalt Impregnated	
61-9	Puncture Resistance of Barrier Material	
61-10	Surface Wax in Paper	D. R. Cushman
61-11	Asphalt Content of Asphalt Impregnated Paper	
61-12	Resistance to Color Bleeding of Barrier Materials	
61-13	Low Temperature Flexibility of Laminated Textile and Paper Material	J. J. Forsythe
61-14	Copper Content of Paper	
61-15	Closure of Fiber Containers for Powder and Explosives	
61-16	Leakage Resistance of Disposal Bags	
61-17	Vibration, Resistance to Low Temperature of Barrier Material Flexible, Water-Vaporproof	
61-18	Self Adhesion of Barrier Material Greaseproof, Flexible	
61-19	Curling Resistance of Pressure Sensitive Water Proof Tape	
61-20	Creep Resistance of Pressure Sensitive Tape and Vinyl Plastic Film	
61-21	Moisture Content of Greaseproof Flexible Barrier Material	P. J. Hakim
61-22	Moisture Retention of Solid Fiberboard	P. J. Hakim
61-23	Curl Resistance of Greaseproof Flexible Barrier Material	P. J. Hakim
61-24	Puncture Resistance of Fiberboard Drums	
61-25	Basis Weight of Paper and Asphalt in Barrier Material	
61-26	A Precision Method for the Analysis of Mixtures of Long and Short Fibered Pulp	
61-27	Identification of Common Polymers in Treated Papers	D. R. Cushman
61-28	Abrasiveness of Pigments and Fillers	F. C. Schmutz

The meeting was adjourned at 12:30 p.m. Assignees are requested to send Matt Boland their completed methods as soon as possible. *Tappi* deadlines require a backlog—several methods are urgently needed to maintain continuous publication.

B. Q. Haynes, *Secretary*

Drying Rates on Yankee Driers

Report on TAPPI Project No. 505

L. G. JANETT

The drying rates on Yankee driers have been increased very markedly with the advent of high pressure driers having high-strength cast-iron shells. Existing literature has rates based on a few machines. This new evaluation is supported by questionnaire data received from mills and covers well over 50 Yankee machines making tissues, as well as machine glaze and heavier weight sheets. Information is given on evaporation as a function of steam pressure. Influence of nip pressures, air systems, arc of contact, and other variables are covered.

THE last survey of drying rates on Yankee machines was incorporated as a small part of the report made in the paper entitled "Drying Rate for Tissue and Absorbent Papers," by A. E. Montgomery, in February, 1936. At that time, a good many tissues were still being made on fourdrinier machines, without Yankee driers.

In the interim, many new machines have been built with higher pressure Yankee driers with machine speeds having increased very markedly.

DRYING RATE BASIS

For consistency, the drying rate basis being followed in this study is the same as that standardized by TAPPI, in that the paper drying rate is the weight of paper dried per square foot per hour based on the total circumferential surface of a drier, considering paper drier surface and felt drier surface with equal value. The same arrangement follows with water drying rates.

Method of Calculating Drying Rate

The total drying surface per inch of width:

$$S/W = 0.0218\ (N_p D_p + N_f D_f) \qquad (1)$$

Where

N_p = number of paper driers.
D_p = diameter of paper driers, in.
N_f = number of felt driers.
D_f = diameter of felt driers, in.

The drying rate expressed in pounds of paper dried per hour per square foot of drying surface:

$$R_p = \frac{\text{Speed} \times \text{Weight}}{S/W \times K} \qquad (2)$$

Speed = speed of machine, f.p.m.
Weight = standard ream weight of sheet, lb.
K = a constant depending on the ream size, for this tissue study, $K = 600$, based on a 3,000-sq. ft. ream size.

GENERAL DATA

The questionnaire sent out resulted in a return of approximately 60 questionnaires on machines having Yankees, which were roughly divided into approximately 40 machines making crepe tissue or toweling, and the balance making MG grades in general. It is significant to note that of all the questionnaires returned, only three machines were being used for MF (machine finish) operations which did not require the use of pressure rolls against the Yankee.

While most of the Yankees in use on tissue grades did not have pre-driers or after-driers, practically all of the machines making specialty MG papers had either pre-driers or after-driers or both in the machine configuration.

Drying Rates

Figure 1 shows paper drying rates R_p against gage steam pressure. Attention is invited to the group of points in the upper left area of the plot. These particular rates represent rather high values because the machines involved had after-driers, so that these particular points represent fiber going over the Yankee but not all the water associated with this fiber being removed on the Yankee.

Figure 2 shows the water-drying rates for the same Yankees as those depicted in Fig. 1. In these data on water-drying rates, R_w, it was calculated in all cases to reflect the water-drying rate of the Yankee drier only, without taking into consideration that portion of the total water evaporated on after-driers.

In previous data, the overall drying rates of combination small drier and Yankee drier machines were plotted so that the high rates of the Yankee intrinsically were not pinpointed as they are in these data.

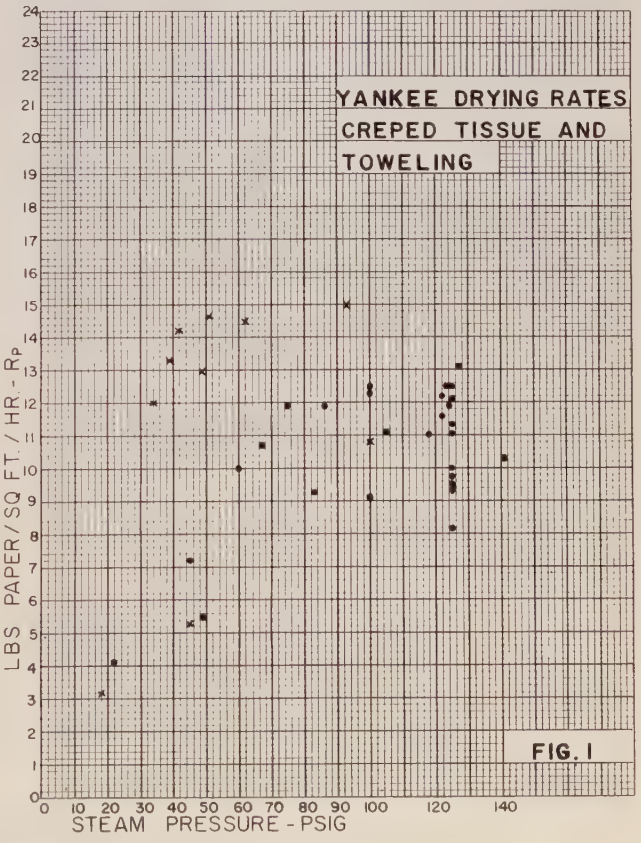

YANKEE DRYING RATES
CREPED TISSUE AND
TOWELING
LBS PAPER / SQ FT / HR - R_p
STEAM PRESSURE - PSIG
0 10 20 30 40 50 60 70 80 90 100 120 140
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
FIG. 1

Fig. 1

L. G. JANETT, J. O. Ross Engineering Corp., Chicago, Ill.

Table I. TAPPI Project No. 505—Yankee Drier Survey Tissue and Towel Machines

Code	Yankee diam., ft.	Contact length, ft.	After driers no. & diam., in.	Felt driers no. & diam., in.	Shell thickness, in.	Product	Furnish	Basis weight, lb./3000 sq. ft.	Yankee speed, f.p.m.	No. of pressure rolls	Nip pressure, in.	Yankee steam, p.s.i.g.	Per cent moisture to Yankee	Per cent moisture from Yankee	Per cent moisture product	Yankee surface temp., °F.	Yankee Rp (As dried prod.)	Yankee Rw
YP 21	12	31.3	0	0	1.793	Tissue Cr.	B.l Pulp	10.21	2270	1	342.8	101	72.1	6.1	6.1	185	12.3	29.1
YP 1	10	26	0	0	3.	Cr.		13.	1500	1	275.	100	67.5	5	5	NA	12.4	23.9
YP 2	10	26	0	0	3.	Cr.		13.	1500	1	300	100	67.5	5	5	NA	12.4	23.9
YP 4	10	27	0	0	1.75	Facial Cr.		10.5	1500	1	250	60	71.5	4	4	225	10.02	23.75
YP 5	8	22	0	0	1.625	" "		10.5	1500	1	250	100	71.5	4	4	310	12.53	29.75
YC 28	10	26	0	0	1.75	Dry Tissue Cr.		10.	1750	1	350	105	71.5	4.5	4.5	195	11.14	26.2
YC 29	10	26	0	0	1.625	" " "		10	1450	1	275	83	71.5	4.5	4.5	195	9.23	21.7
YC 30	6	14	0	0	1.375	" " "		10	680	1	225	45	73	4.5	4.5	205	7.21	18.28
YD 5	10	29	0	0	1.6875	" " "		14	1240	2	175	125	86	5.	5	NA	11.05	24
YD 6	10	29	0	0	1.6875	" " "		14	1280	2	210	125	86	5	5	NA	11.41	66
YD 9	16	45	0	0	2.	Facial, Bath		14	2170	1 Suct.	330	86	NA	7	7	NA	12.10	6NA
YD 10	12	32	0	0	2.	Toilet		14	1760	1 "	350	127	NA	7	7	NA	13.08	NA
YD 11	10	26.5	0	0	2.	"		14	1200	1	NA	67	NA	NA	NA	NA	10.7	NA
YD 1	10	NA	0	0	1.625	" Cr.		14	1450	2	250	122	75	5.5	5.5	180	12.92	35.95
YD 3	10	27	0	0	1.625	"		14	1300	2	250	122	78	5.5	5.5	180	11.59	38.2
YD 8	12	26.6	0	0	2.	Napkin	Bl. Kr.	16.7	1160	2	210	141	65	6	6	NA	10.3	17.35
YJ 26	12	32.5	0	0	2.125	Dry Tissue Cr.		11.25	2100	2	350	125	67	5	5	200	12.52	23.5
YJ 27	10	26.3	0	0	1.625	" " "		11.3	1700	1	300	125	67	5	5	200	12.22	22.93
YJ 27	10	26.3	0	0	1.625	" " "		8.6	1500	1	300	125	67	5	5	200	8.21	15.4
YJ 28	10	26.75	0	0	1.75	" " "		11.25	1280	1	300	100	67	5	5	200	9.16	17.2
YJ 29	10	25.75	0	0	1.625	" " "		11.25	1310	1	300	125	67	5	5	200	9.39	17.6
YJ 30	10	26.08	0	0	2.125	" " "		8.6	1750	1	300	125	67	5	5	200	9.58	18
YJ 30	10	26.08	0	0	2.125	" " "		11.25	1400	1	300	125	67	5	5	200	10.02	18.8
YJ 31	10	26.92	0	0	2.	" " "		14.	1100	1	350	100	68	5	5	NA	9.81	19.35
YJ 74	12	30.	0	0	2	Tissue		30	750	1	250	75	68	5	5	220	11.93	23.55
YJ 15	10	NA	0	0	2.	"		13	520	1	NA	21	NA	5	5	203	4.30	NA
YJ 16	10	NA	0	0	2.	"		11.5	460	1	NA	18	73	5	5	165	3.37	8.48
YJ 22	12	33.1	0	0	2.4	" Cr.		10.5	1000	1	250	49	65	5	5	180	5.57	9.55
YD 12	12	31.4	12–60	4–60	2.1875	Alfibre Tow.		NA	1280	1	500	32	66	51	6.5	272		
YD 14	12	32.3	0	0	1.875	Gvt. Toilet		13.	1810	1	370	124	74.6	6.3	6.3	200	12.5	33.65
YD 14	12	32.3	0	0	1.875	Toiltex		14.	1605	1	370	124	75.0	6.3	6.3	205	11.91	32.9
YD 15	12	34.6	0	0	2.03125	Facial		10.5	1975	2	315	118	73	3.5	3.5	200	11.0 Rp (moisture-free	28.3
YP 13	12	31.3	9–60	0	1.809	Tissue Cr.	Bl. Pulp	14.07	1865	1	310	39	69.8	35.5	4.2	185	13.31	23.42
YP 14	12	31.3	2–60	0	1.656	" "	" "	10.75	2900	1	390	93	73.6	19.8	9.5	185	14.98	38.05
YD 2	10	27.	23–48	2–48	1.625	Towel Cr.	Bl. Pulp	34.0	1200	2	250	6	80	54	4	130	24.95	70.5
YP 15	12	31.3	7–60	0	1.777	Tissue Cr.	" "	13.65	1865	1	309	49	71.2	33.5	3.7	185	13.0	25.55
YP 16	12	31.3	10–60	0	1.822	" "	" "	13.65	1700	1	378.4	34	69.5	31.5	2.4	185	12.02	21.87
YP 17	12	31.3	10–60	0	1.719	" "	" "	13.55	2060	1	398.2	62	72.4	25.1	2.2	185	14.5	33.1
*YJ 17	12	NA	5–48	0	2.1875	"		13.	800	1	160	45	57	5	5	NA	5.25	6.64
YP 18	12	31.3	8–60	0	1.850	" Cr.	" "	13.45	2040	1	343.2	42	72.1	33.0	2.1	185	14.25	29.8
YP 19	12	31.3	4–60	0	1.629	" "	" "	10.42	2030	1	360.0	100	72.9	5.2	4.1	185	10.8	28.45
YP 20	12	31.3	10–60		1.671	" "	" "	13.33	2150	1	367.1	51	72.6	32.2	3.7	185	14.62	31.80

[a] 7–48-in. predriers and 1–48-in. felt. Per cent moisture to predriers = 70%. NA—Not available.

Table II. Tappi Project No. 505—Yankee Drier Survey MG and MF Machines

Code	Predriers no. & diam., in. Paper	Predriers no. & diam., in. Felt	Yankee diam., ft.	Contact length, ft.	After driers no. & diam. in.	Shell thickness, in.	Product	Furnish	Basis weight, lb./3000 sq. ft.	Yankee speed, f.p.m.	No. of pressure rolls	Nip pressure, lb./in.	Steam pressure, p.s.i.g. Predriers	Steam pressure, p.s.i.g. Yankee	Steam pressure, p.s.i.g. After driers	Per cent moisture To predrier	Per cent moisture Yankee To	Per cent moisture Yankee From	Per cent moisture From after drier	Yankee surface temp., °F.	Overall Rp (moisture-free)	Yankee Rp (moisture-free)	Yankee Rw
YJ 1	26–48	5–48	12	28.3	2–48	2.4375	MG Bag	Bl. Kr.	50	798	1	330	46	70	76	68	37	8	4	200	1.692	20.3	10 15
YJ 1	26–48	5–48	12	28.3	2–48	2.4375	MF Wrap	Kr.	60	635	0	0	54	75	56	68	37	8	4	210	1.62	19.3	9.65
YJ 2	17–48	4–48	12	28.3	2–48	2.1875	MG Bag	Bl. Kr.	35	815	1	175	46	82	46	68	40	8	3.5	210	1.682	14.59	8.46
YJ 2	17–48	4–48	12	28.3	2–48	2.1875	MF Oiling	Bl. Kr.	24.7	748	0	0	35	None	35	68			4		1.083	0.	0
YJ 3	8–48	1–48 1–24	10	23.6	2–48	2.	MG Wrap	Bl. sulfate	25	835	1	100	58	75	20	69	46.2	7.2	5.8	225	2.24	12.52	9.80
YJ 4	0	0	12	28.2	4–48	2.	" Wax	" "	25	680	1	265	None	100	18		72.7	13.0	5.5	210	3.66	8.54	21.5
YJ 10	29–60	6–60	12	29.1	4–60	2.	MG	Bl. Kr.	30	1325	1 & 1 Strip	60	−1	90	43	67 to 70	NA	NA	NA	205÷265	NA	NA	NA
YJ 10	29–60	6–60	12	29.1	4–60	2.	MF	Kr.	62	1175	0	0	95	By-passed	80	67 to 70			NA		NA	0	0
YJ 19	6–48 1–36	1–48	10	25.8	1–48	1.9375	MG	Secondary Kr.	31.7	440	1	109	35	50	35	67.25	47	6.0	4.8	200	1.875	8.46	6.06
YJ 20	0	0	10.5	26.7	6–48	1.625	MG	" "	17.75	500	1	80	None	28	30		64	8.71	5.17	200	1.55	5.10	88.59
YJ 21	12–60	2–48	12	31.17	4–84	2.0625	MG	" "	26.2	650	1	109	31	25	25	71.8	46.2	6.15	5.72	200	1.065	8.51	6.75
YJ 21	12–60	2–48	12	31.17	4–48	2.0625	MF	" "	28	650	0	0	NA	NA	NA	70.8	27	25	5.5	NA	1.14	9.13	0.34
YC 15	0	0	10	23.5	0	2.125	MG	90% Kr.	18	700	1	NA	None	80	None		68	5		230	7.62	7.62	15.9
YD 22	6–48	1–48 2–60	12	32	3–48	2.	MG Bag	Kr.	30	970	1	150	96	65	10	72	64	10	7	220	2.78	15.43	25.7
YJ 11	8–60	1–60	12	28	0	2.125	MG Wax		16.75	1480	1	NA	67	85	None	NA	NA	4		NA	2.76	13.15	NA
YJ 72	0	0	12	30	0	2.125	MG Wrap		23	535	1	250	None	65	None		75	3		203	6.33	6.33	18.8
YJ 13	0	0	12	29.4	0	NA	MG	Kr.	40	400	2	250	None	45	None		77	5		NA	8.49	8.49	28.0
YJ 13	0	0	12	30.4	0	NA	MG	Kr.	13	600	2	250	None	58	None		76	5		NA	4.13	4.13	12.9
YJ 74	0	0	12	30	0	2.0625	MG Coat		20 to 35	NA	NA	NA	None	NA	None		NA	NA		NA	NA	NA	NA
YD 13	8–48	2–48	12	33	1–144[a]	2.375	MG Wax	Bl. Kr.	24.5	1005	1	300	36	63	32	65	45	5.5	6	200–220		12.27	9.32
YD 16	0	0	10	24	0	2.	MG Wrap	Unbl. Sulfite	19	600	1	350	None	47	None		69	6.3		270	6.80	6.80	14.7
YD 17	29–48	4–36 2–48	12	26	0	2.375	MG Wrap	Bl. Kr.	40	560	1	NA	24 to 36	50	None	74	45.8	6.4		280	.902	1.112	0.865

[a] Coating is applied on a second Yankee. NA—Not available.

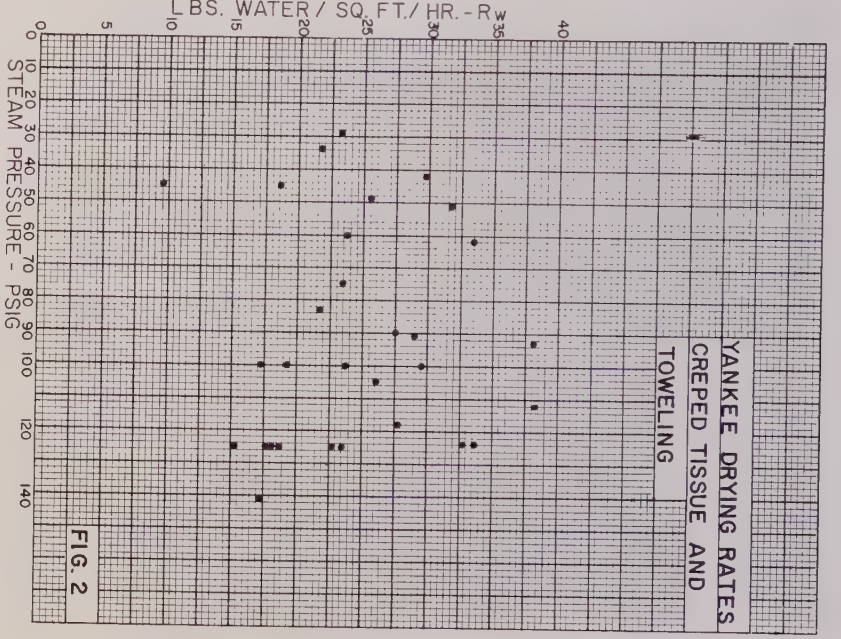


Fig. 2

From the plotted points, it is most difficult to establish curves or straight lines to represent the relationship between steam pressure and drying rates. This bears out the previous data configuration also and would seem to indicate that while drying rate is a function of steam pressure and surface temperature, the other variables in the operation probably out-

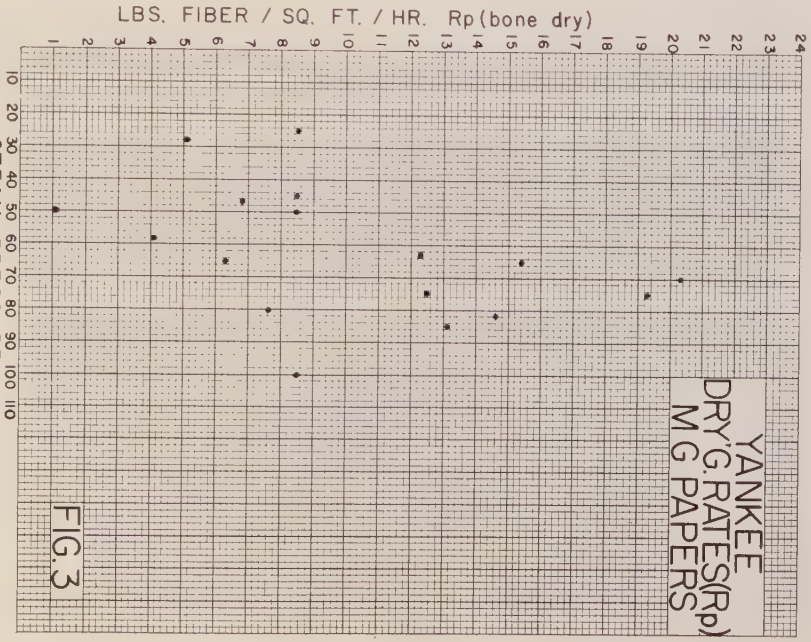


Fig. 3

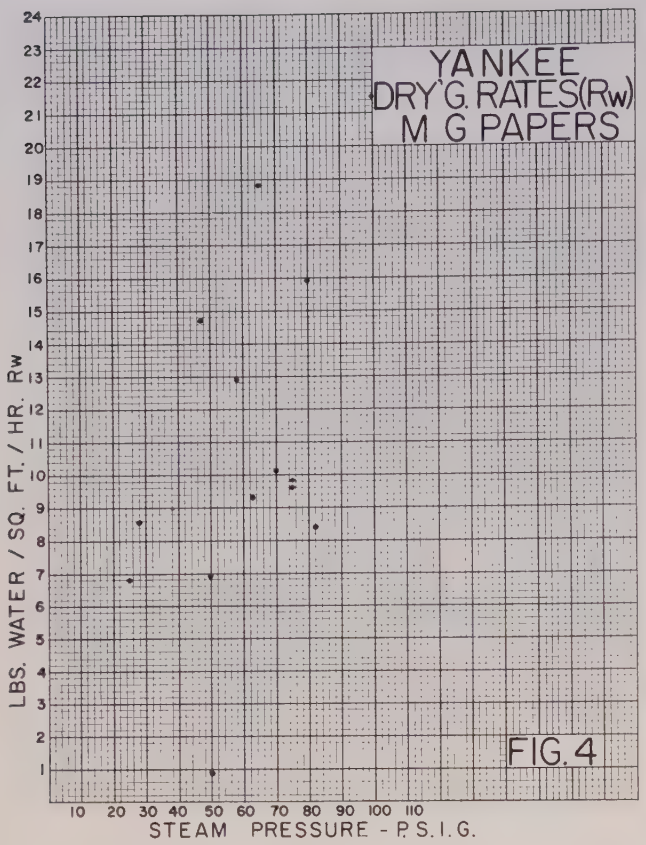


Fig. 4

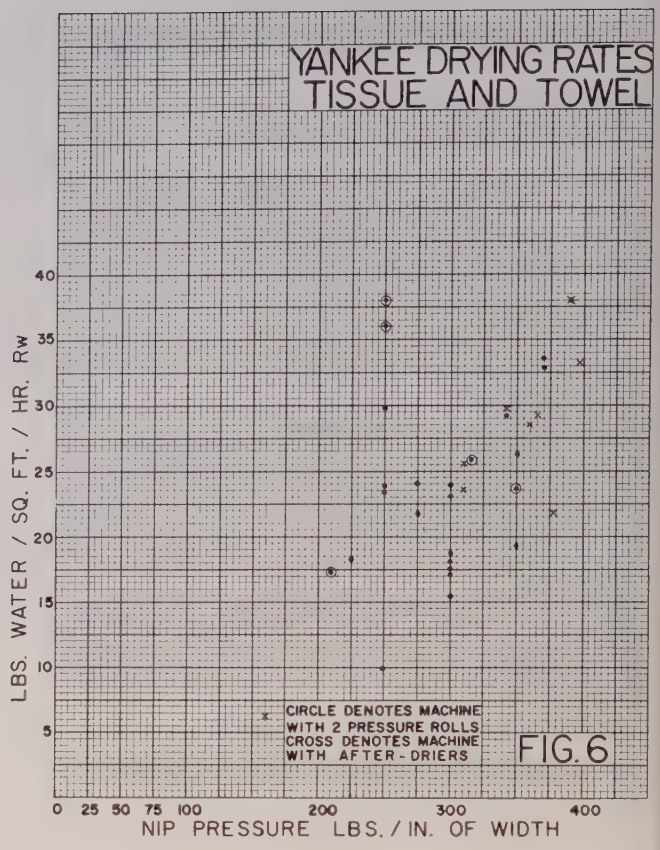


Fig. 6

weigh the surface temperature alone. These other variables include pressure rolled arrangement, nip pressure, water removal characteristics of the pressure roll arrangement, and the air systems employed on the Yankee surface itself for accelerating heat transfer and moisture removal. It is significant to note that of all the machines reported on, none are operating without an air system. No attempt was made to evaluate the Yankee air systems because of the extreme difficulty in getting such information from questionnaires at this time.

Referring to Fig. 1, it would seem that the range of paper drying rates, R_p, discounting the rates which reflect partial

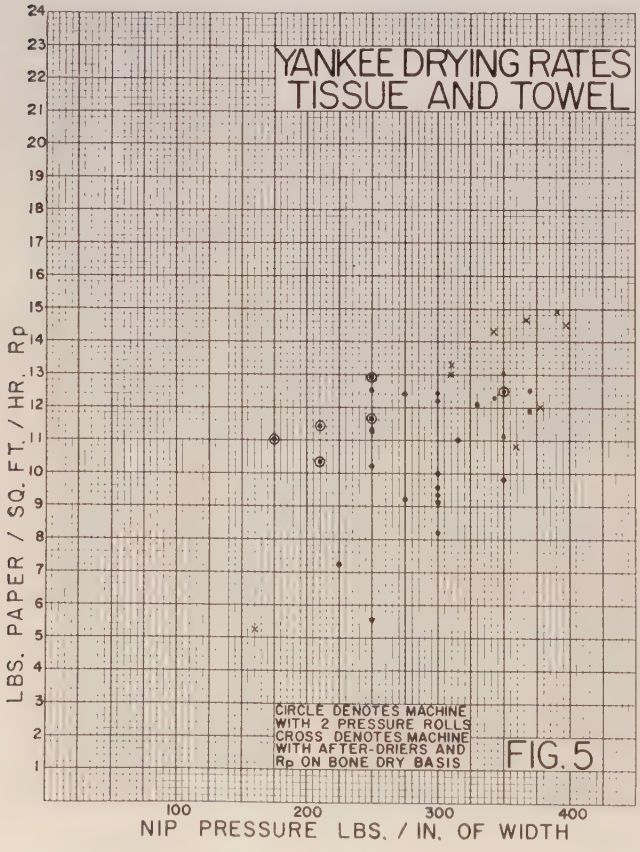

YANKEE DRYING RATES
TISSUE AND TOWEL
LBS. PAPER / SQ. FT. / HR. Rp
CIRCLE DENOTES MACHINE
WITH 2 PRESSURE ROLLS
CROSS DENOTES MACHINE
WITH AFTER-DRIERS AND
Rp ON BONE DRY BASIS
FIG. 5
NIP PRESSURE LBS. / IN. OF WIDTH

Fig. 5

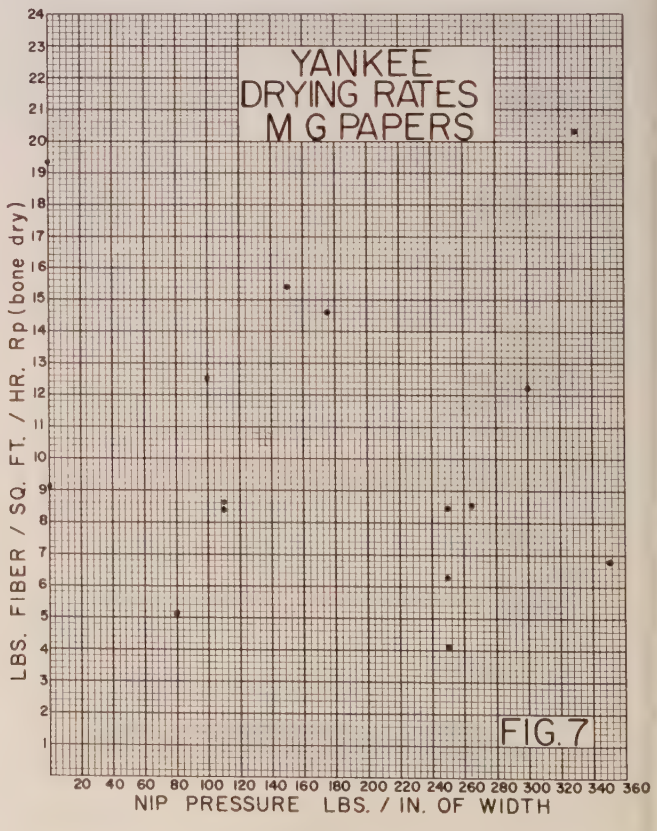


Fig. 7

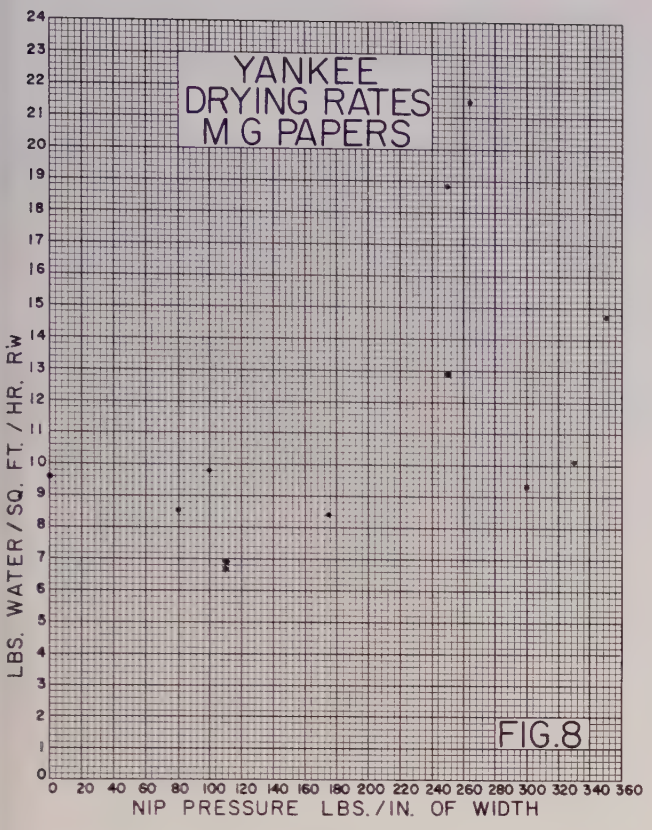


Fig. 8

drying on other driers than the Yankee, lie within 9 and 13 lb. per sq. ft. per hr. within a steam-pressure range of 60 to 125 lb. p.s.i.g.

The water-drying rates, R_w, in Fig. 2, appear to lie between 15 and 30 lb. of water per square foot per hour with the steam pressure over a wider range of from 30 to 125 p.s.i. It should be pointed out that we should not term the water drying rate by those terms in a strict sense, because a great deal of the water is removed by the pressure roll and is not removed by a thermal method *per se*.

MG Papers. Figures 3 and 4 show the paper- and water-drying rates, respectively, for the other groups of machines reported to us, plotting the rates against steam pressure. Here again the pattern is difficult to establish with respect to a straight-line relationship and this, in part, is due to the fact that the moisture content of the sheets going onto and leaving Yankees is difficult to obtain, at best. While we feel the data are as accurate as can be obtained, we have no illusions as to the possible errors that may exist. We rather seriously suspect the validity of the very high water-drying rates, particularly because an error in moisture content entering a machine can effect the overall rate very markedly.

GENERAL OBSERVATIONS

The arc of contact was given us in the questionnaires and it is interesting to see the wide variation in this figure. With 12-ft. Yankees, the arc of contact varied from 26 to 34.6 ft. The variation in arc of contact on 10-ft Yankees varied from 23.5 to 29 ft., although the latter figure was questioned by the mill who sent it in. Of the approximately 60 machines reported, ten indicated that they used two pressure rolls at times. The nip pressure reported varied from 80 up to 390 lb. per lineal inch.

Of the machines reported on, only three indicated presence of superheat in the steam to the Yankee driers. Where moisture content was reported, it was the moisture content of the sheet entering the pressure roll nip and varied in general from approximately 65% to 75% moisture.

The range of drier shell thickness variation was from $1^5/_8$ to $2^7/_{16}$ in. One report indicated a 3-in. thick shell, but questioned the figure in their return.

Additional Correlations

Prior to publication of the data obtained, it is proposed to further analyze the in formation obtained in order to try to find possible drying rate correlations with arc of contact, shell thickness, nip pressures, and surface temperatures.

CONCLUSIONS

The data so far analyzed would indicate that the many variables other than the steam pressure and surface temperature affect drying rates sufficiently to make trend lines difficult to establish. For future considerations, it would seem best to attack the problem of evaluation of drying rate by dividing it into three separate and distinct areas; namely, the heat transmission of the drier, the portion of drying rate attributable to the air system on the machine which has been indicated to be quite high, with modern high pressure Yankee air systems, and the evaluation of that portion of the water removed by the pressure roll functioning as a drying operation. In connection with the latter, the stock temperature and shower-water temperature are unquestionably important in the water-removal rate.

Progress in Nuclear Power*

This report lists the nuclear power plants in the United States scheduled to go into operation 1960–1961 with a summary of the foreign installations in addition mention is made of organic moderating material and nuclear fuel costs.

The steel vessel for the organic cooled, organic moderated nuclear reactor for the City of Piqua, Ohio (11,400 kw. electrical output, 45,500 kw. thermal output) was delivered about two weeks ago so it is believed that this subject of nuclear power is coming very close to home when it comes within 70 or 80 miles of Cincinnati. Completion of this plant is scheduled for 1961.

The Cincinnati Gas & Electric Co. is being threatened even closer home than this by the possibility of the installation of a 50,000-kw. electrical output unit for the City of Hamilton, Ohio. Hamilton has been invited to inquire into the possibility of getting help, similar to the City of Piqua, from the Atomic Energy Commission offer to build an organic moderated, organic cooled reactor for them.

ORGANIC MODERATING MATERIAL

What is the organic material being used in these reactors and what are its possibilities? The name is terphenyl, a three-benzine ring chemical compound. It is supplied to the user as a powder with a yellow cast. After being in the reactor for a period of time it becomes partly a solid and partly yellow powder at atmosphere pressures and temperatures.

The material is combustible and slow burning with a flash point and burning characteristics comparable to kerosene. The qualities which make it attractive as a moderator and a cooler for nuclear steam electric generating units are:

1. Temperatures of 600 to 700°F. can be carried in the piping steam without having the coolant under pressure. The only pressure in the circulating system between the reactor and the steam generating unit is the minimum requirement to overcome the pipe friction and maintain the proper fluid velocity to get the best heat transfer.
2. There is no corrosion of the piping or circulating tubes.
3. Specific heat is 0.5 to 0.6.

* Steam and Power Committee report (Can 726) submitted by George B. Gregg, W. A. Zeisness, and Leonard Limon.

A report to the Atomic Energy Commission in 1959 by a contractor based on 300,000 kw. electrical energy output with steam turbine inlet conditions of 600 p.s.i.g., 650°F. temperature using four stages of feedwater heating for the steam cycle indicates relative costs for the organic moderated, organic cooled reactor as follows:

Type of steam generating units in plant	*First cost, dollars/kw.*	*Operating cost, mills/kw.-hr.*
Pressurized water reactor	207	8.17
Boiling water reactor	301	9.28
Heavy water reactor	322	11.17
Organic reactor	232	8.12
Coal fired conventional	168	6.77

The organic reactor system made use of a reactor 14 ft. diam. 60 ft. high. The organic material was conducted from the reactor to four separate steam generating units through 30-in. diam. pipes in the original design which is referred to as a four loop system.

Later additional calculations were made and designs drawn reducing the organic circulating system to three loops with three steam generators. This reduced the estimated first cost to $207 per kw. of installed capacity.

A SMALL CAPACITY PLANT FOR ISOLATED LOCATIONS

Top level officers of the Armed Forces and other government officials gathered at the Alco Products, Inc. plant, Dunkirk, N. Y., on March 29, 1960, to witness tests on the Free World's first prefabricated nuclear power plant. It was built for the Army Engineers under a $3.2 million dollar contract and after comprehensive testing was shipped to Camp Century in Greenland, where it was installed in a snow tunnel.

The plant is capable of delivering 1560 electrical kilowatts plus about 1 million B.t.u. of heat per hour for space heating. It was scheduled for 1960 operation but delays have forced the operating date into early 1961. The condenser system uses air and ethylene glycol because of the severe low temperatures at the operating location.

The plant was broken down into 27 air transportable packages with all units designed and built to meet size and weight limitations required for shipment by military cargo aircraft.

The PM-2A follows two other pressurized water nuclear power systems in the Military Atomic Power Program. The prototype SM-1 built in 1957 for the Army, installed at Fort Belvior was the first, the SM-1A is now under construction at Fort Greely, Alaska.

It is now estimated that over a 20-year plant life nuclear plants in the arctic regions can produce heat and electricity at 25% of the cost of conventional plants. Fuel oil costs $1 to $3 per gal. at McMurdo Sound in Antarctica and $7 to $10 at less accessible stations.

UNITED STATES PLANTS IN OPERATION IN 1960

Two plants for large-scale production of atomic energy went operational in 1960.

The Commonwealth Edison Co.'s 180,000-kw. unit at Dresden, Ill., with a boiling water reactor system built by the General Electric has a thermal kilowatt capacity of 626,000.

The Yankee Atomic Electric Co.'s 110,000-kw. unit at Rowe, Mass., with a pressurized water reactor system built by the Westinghouse Corp. has a thermal capacity of 392,000 kw.

The only other large utility plant in operation at the present time is the 60,000-kw. machine of the Duquesne Light Co. at Shippingsport, Pa., with a pressurized water reactor built by the Westinghouse Corp. with a thermal capacity of 230,000 kw.

UNITED STATES PLANTS SCHEDULED TO BE OPERATIONAL IN 1961

The following nuclear plants are scheduled to become operational in 1961:

Consolidated Edison's plant at Indian Point, N. Y., has a 151,000-kw. pressurized water reactor which will be supplemented by 104,000 kw. from an oil-fired superheater under contract with the Babcock and Wilcox Co.

The Enrico Fermi plant of the Fermi Power Reactor Development Co. has a 100,000-kw. fast breeder reactor which will feed power into the Detroit Edison Co. The location is Lagoona Beach, Mich.

The City of Piqua, Ohio, has a contract with Atomics International to build an 11,400-kw. generating unit of the organic moderated, organic cooled type to feed power into its municipal system.

The Saxton Nuclear Experiment Corp. at Saxton, Pa., has a 5000-kw. boiling water reactor being constructed for them by the Westinghouse Corp.

The Army Corps of Engineers have the SM-1A at Fort Greely, Alaska, with a pressurized water reactor with 1700 kw. and the PM-2A at Camp Century, Greenland, under construction by Alco Products, Inc.

The Atomic Energy Commission and the Air Force now have under contract with the Martin Co, a pressurized water reactor capable of 1000 kw. at Sundance, Wyo.

The Atomic Energy Commission also has plans for a gas cooled, light water moderated reactor to produce 330 kw. at NRTS, Idaho. Aerojet has the contract and work is to be completed in 1961.

PROJECTS FOR COMPLETION BEYOND 1961

A partial list of future projects now planned for completion beyond 1961 may be found in a publication called *Atomics* which can be purchased for $1.00 by writing to Atomics, 308 East James St., Great Barrington, Ill.

FOREIGN NUCLEAR PROGRESS

The most intensive development of nuclear power is in England. Harwell has more research reactors than Oakridge and Argonne combined, and its operations are being extended to a new site. Calder Hall Station now has four 200,000-kw. thermal reactors operating. However, the plan is to build one nuclear power station per year to give Britain about 5,000,000 kw. capacity by 1968. Stations now under contract are 275,000 kw. at Berkeley (1961–62), 300,000 kw. at Bradwell (1961–62), 500,000 kw. at Hinkley Point (1961–62), 500,000 kw. at Transfynydd (1963–64) and 300,000 kw. at Hunterston.

Nuclear power projects are based on low temperature, gas-cooled, graphite moderated reactors. Fuel elements in first Calder Hall reactors achieved average burn-up of 1500 MWD days per ton with maximum of 2000 MWD per ton. Goal now planned is average of 3000 MWD per ton. Each ton of uranium metal produces as much heat as burning 10,000 tons of coal at this rate and would result in fuel replacement cost in the latest design nuclear plant of about 1.5 mills per kw.-hr.

Work is now being done in Britain on an advanced type of gas cooled reactor capable of operation at 1000°F. gas coolant temperature at 270 p.s.i. Site work on the 28,000-kw. electrical output plant at Windscale is proceeding rapidly and reactor is due to become critical in 1961.

Russia has two nuclear power reactors in operation.

France has one reactor operating and expects to build a 100,000-kw. plant about 30 miles east of Brest soon.

Interatom has contract with West Germany for a 150,000-megawatt organic moderated unit scheduled for 1963 completion. The advisory Atomic Commission has approved a program to build one 50,000 and four or five 20,000-kw. reactors of German design.

Westinghouse is contractor for a 165,000-kw. pressurized water reactor to be built in Italy on the Po River between

Turin and Milan. Construction is progressing on the Senn reactor and a 30,000-kw. organic moderated reactor is planned at Bologna as a joint government industry project.

Spain opened a $1,850,000 uranium ore processing plant with a capacity of 200 tons per day at Andujar near Seville in 1959. Atomics International is under contract to the Cabinet in Madrid to assist in preparing plans for a 30,000-kw. reactor for power and testing purposes. It will be organic cooled with heavy water as the moderator.

British General Electric is building a 166,000-kw. Calder Hall-type reactor for Japan. American General Electric is building a smaller boiling water reactor in Japan. In 1959 the utility companies completed a study of the countries' needs and their coordination with nuclear power.

India plans a four-reactor program in the next five years with Russia participating in the design of one of the two 150,000-kw. natural uranium plants if present negotiations are completed. Two other smaller enriched uranium reactor plants are also projected. Coal for some of India's present thermal plants must be hauled 800 to 1500 miles from the mines. This makes nuclear power attractive in many locations.

Brazil is inviting bids for a 150,000-kw. power reactor for a site on the Mambucaba River, 85 miles west of Rio de Janiero, for completion by the end of 1966.

NUCLEAR FUEL COSTS

Many estimates have been made and are being made each year as to when nuclear fuels will compete with fossil fuels such as coal, oil, and gas. There is no general answer to this problem as each plant for generating steam for power and process uses must be designed to use the fuel that is most economical over the life of the plant. 1960 found plentiful supplies of fossil fuels in many parts of the world but increased usage promises to deplete the low cost sources of oil, gas, and coal as more countries upgrade their citizens and their requirements for heat for homes, industries and power generation increase. For instance the PM-2 reactor at Camp Century, Greenland, replaces an oil-fired boiler. Oil costs average $2.50 per gal. delivered and the 850,000 gal. annual fuel requirement would take in excess of 15,000 55-gal. drums. Since all of this fuel would be air lifted the total cost for fuel alone would be $2,125,000 annually.

Writing in *Atomics* in the July–December edition Mr. J. E. Maider, manager of the Atomic Power Equipment Department of the General Electric Co. at San Jose, Calif., says, "During the period 1956 to 1960, the fuel cost for new conventional plants in an area of high fossil fuel costs such as New England, has risen slightly, due to inflation, so that at the present time, the fuel cost of a nuclear plant is lower than that for a conventional plant in such an area."

He continues, "Nuclear power at about 13 mills per kw.-hr. in early 1956 was not competitive with any portion of the new steam generating capacity to be purchased in that year. By early 1959, the combined reductions in capital cost and fuel cost to about 10 mills per kw.-hr. and today with further reductions in capital costs and fuel costs attained during the past year, nuclear power at about 8 mills per kw.-hr. is on the threshold of competing for a portion of the power plant market even though slight gains in efficiency might be made for some time in future conventional plants."

So in 1960 we are well on the road to applying nuclear energy for steam and power where it is practical and economical.

1961 should see some more progress in this field with more attention being given to some of the smaller size units with electrical output in the paper mill range of turbine generator units, 5000 to 40,000 kw. Of course, the fully integrated mill will still have to burn the off all of the wood but the large paper mill operations starting with pulp should begin to be educated now in the advantages nuclear power has to offer.

SELECT-A-FLOW MANIFOLD

Fabri Select-A-Flow now provides the paper and pulp industry with a unique flow routing system which cuts operating costs, reduces stock contamination and simplifies route selection.

With Select-A-Flow, route changes which formerly took several hours of maintenance personnel time, now are made in a few minutes by operating personnel . . . machine "down time" is reduced to a bare minimum.

The Select-A-Flow system leaves no stock plugs in the line, and is essentially self flushing. Because of this feature, contamination is virtually nil compared to old-style manifold systems. This makes it ideal for frequent color changes.

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The Effect of Closed White Water Systems on Groundwood Brightness by Determination of Factors Causing Discoloration

TAPPI Research Grant No. 162

F. W. LOREY

The purpose of this study was to ascertain the prevalent factors leading to low brightness of groundwood pulps when white water circulation is increased. Little differences in brightness were found between open and closed white water systems but pulp from a closed system showed greater brightness increase upon bleaching in spite of a solids buildup.

Groundwood mills throughout the pulp and paper industry operate differently with regard to the percentage of decker white water that is recirculated for grinder and screen dilution. Some recirculate all of the white water and thus operate a "closed" system, while others draw off a small percentage of the white water from the system and operate what is known as an "open" system. With the open system, fiber losses are greater, but slime build-up and other deleterious occurrences are minimized.

The question has arisen as to the relationship between white water recirculation and pulp brightness. Since increased white water recirculation will result in greater build-up of those materials causing brightness loss, it follows that pulps made with a closed white water system are usually lower in brightness than pulps made with a corresponding open white water system. It is the purpose of this study to ascertain which are the prevalent factors leading to low brightness of groundwood pulps when white water recirculation is increased.

In this study, pulp and water samples from both closed and open white water systems were submitted by the Keyes Fibre Co., Waterville, Me. The white water samples along with a fresh water sample from the same mill were analyzed for suspended solids, dissolved solids, and iron, copper, and manganese contents. Brightnesses of the pulp samples were measured with no chemical treatment, and also after treatment with sulfur dioxide as a brightening agent, with oxalic acid and Versen-OL as sequestering agents for iron, and with a one-stage peroxide bleach. Also, since a large build-up of manganese was found in the white water samples, brightness measurements were made on sheets deliberately washed with manganese sulfate solution, to ascertain the effect of manganese on groundwood brightness. All brightness sheets were subjected to an accelerated aging test by heating in an oven at 105°C., with brightness measurements being made at 4.5, 11, and 24 hr.

PROCEDURE

Water Analyses

Suspended solids in the water samples were determined by filtering 1 kg. of a representative sample of water through a previously dried and weighed filter paper on a Buchner funnel. The collected residues on the filter papers were then dried and weighed, and the dried suspended solids reported as the per cent of the total weight of the water sample.

Dissolved solids were determined by evaporating accurately weighed water samples on a steam bath and then drying in an oven at 105°C. The results were reported as milligrams of dissolved solids (dry basis) per kilogram of water, i.e., parts per million.

The iron, copper, and manganese contents of the water samples were measured spectrographically with a grating spectrophotometer, and reported as milligrams per kilogram of water or parts per million.

All water analyses data are listed in Table I.

Brightness Measurements

Handsheets for brightness measurements were made according to the procedure described in TAPPI Standard T 218 m-58, with the exception that 4 g. (O.D. basis) of pulp were used for each sheet instead of 2 g. For each of the two pulp samples evaluated (one from the closed white water system and the other from the open white water system), sheets were made using distilled water as specified in the standard, and also with the following chemical treatments: (1) addition of sulfur dioxide to pulp samples diluted with distilled water, until the pH was reduced to 4.5, (2) addition of oxalic acid to pulp samples diluted with distilled water to pH 4.5, and (3) addition of 0.10 ml. of Versen-OL sequestering agent (N-hydroxyethylethylenediaminetriacetic acid) to each 4 g. of pulp, which increased the pH from 6.7 to 8.8.

Since appreciable manganese was detected in the white water samples, it was decided to make handsheets from both pulps using (1) dilution water containing 2 p.p.m. $MnSO_4$ and (2) dilution water containing 2 p.p.m. $MnSO_4$ with the handsheets then being washed with distilled water. This study was done in order to establish the effect of a known addition of manganese on pulp brightness.

The pulps from the open and closed white water systems were bleached under the conditions used for the study on the effect of underwater storage of wood on pulp brightness. The chemicals used were 2% peroxide as sodium peroxide, 5% sodium silicate, 0.05% Epsom salts, and 1.58% total alkali, all expressed as percentages of the ovendry pulp weight. Other conditions were 5% consistency, 120°F. temperature, and 3 hr. bleaching time, after which residual peroxide was destroyed by reducing the pH to 5.5 with sulfur dioxide. In making the brightness handsheets, the pH of the diluted slurries was further reduced to 4.5 with sulfuric acid.

All of the brightness sheets were aged by heating at 105°C., with brightness measurements being made of 4.5, 11, and 24 hr. These aging tests were made in an effort to detect any brightness differences which may not show up with freshly made sheets. Aging tests for several of the sheets were not made unitl a week after the initial brightness measurements were made on the sheets, and this explains the brightness differences between the initial tests and the zero hour aging tests.

Brightness measurements were made with a Hunter Multi-Purpose Reflectometer, using a tristimulus blue filter having a wavelength of 457 mu and the results are listed in Table II.

F. W. Lorey, Pilot Plant Group Leader, The Research Foundation of State University of New York, Albany, N. Y., representing State University College of Forestry at Syracuse University, Syracuse, N. Y.

Table I. Water Analyses

	Fresh water	*Open system white water*	*Closed system white water*
Suspended solids, %	0.00032	0.0334	0.0424
Dissolved solids, p.p.m.	34	1005	1760
Dissolved iron, p.p.m. as iron	0.15	0.20	0.25
Dissolved copper p.p.m. as copper	0.03	0.06	0.08
Dissolved manganese, p.p.m. as manganese	0.02	1.3	2.2

Iron, copper, and manganese determinations were made with a grating spectrophotometer

Freeness and Classification Measurements

Pulp freeness was measured according to TAPPI Standard T 227 m-50. Fiber classifications were done with a Bauer-McNett fiber classifier equipped with 20, 35, 65, and 150-mesh screens, using a 10.0 g. (O.D. basis) pulp sample for a duration of 20 min. Freeness and classification results are listed in Table III.

DISCUSSION

The water analyses showed the expected build-up of both suspended and dissolved matter in progressing from the fresh water to the open system white water to the closed system white water samples. The high dissolved solids contents of 1005 p.p.m. for the open system white water and 1760 p.p.m. for the closed system white water were due mainly to dissolved wood matter. Iron, the chief contributor to brightness loss of groundwood pulp did not seem excessive, since the concentrations of 0.20 and 0.25 p.p.m. in the white water samples are borderline regarding the amounts which can be tolerated with no brightness loss. The build-up of manganese seemed excessive, however, with the open system white water sample containing 1.3 p.p.m. manganese and the closed system white water sample 2.2 p.p.m. manganese. Although manganese is known to affect brightness of wood pulps, particularly chlorine dioxide bleached pulps, it apparently has little effect on groundwood pulps, since there was little difference in brightness between the open and closed system pulps and handsheets washed with manganese sulfate solution also showed no brightness losses. The origin of the manganese in the pulps is uncertain. The dissolved copper content of the water samples did not reach levels considered harmful to brightness.

In comparing the brightness values of the open and closed system pulps, it may be concluded that these two pulps were of the same brightness, and that no significant changes in brightness occurred with the addition of sulfur dioxide, oxalic acid, or Versen-OL sequestering agents, or manganese sulfate.

Table III. Fiber Classification and Freeness Results

	Open System pulp	*Closed System pulp*
Freeness, ml., Can. Std.	324	289
Fiber classification		
Retained on 20-mesh screen, %	16.1	13.3
Retained on 35-mesh screen, %	21.5	18.3
Retained on 65-mesh screen, %	15.3	13.1
Retained on 150-mesh screen, %	17.3	14.9
Through 150-mesh screen, %	29.8	40.4

These results again indicate that the iron contents of the systems were below that required for influencing brightness and that manganese has little effect on groundwood pulp brightness.

The bleaching work using 2% Na_2O_2 at 120°F. and 5% consistency for three hours resulted in a 6.0-point brightness increment for the open system pulp and a 7.4 brightness increment for the closed system pulp. Any significance to this difference in brightness increment is not understood.

Upon aging, all of the unbleached handsheets showed brightness decreases of 3 to 5 points over 24 hr., although again no significance to the differences between the samples could be established. With the bleached samples, the open system pulp showed a slightly greater loss upon aging than the closed system pulp.

As expected, the freeness and classification results showed the pulp from the closed white water system to have a lower freeness, more fines, and less coarse material than the pulp from the open white water system. Original plans called for brightness measurements on the classified fractions of each of these two pulps, but it was necessary to use tap water in the operation of the fiber classifier, and the brightness decrease due to the use of tap water was 6 or 7 points. Therefore, acceptable brightness data for the classified fractions could not be obtained.

SUMMARY OF RESULTS

1. The pulp samples from the open and closed white water systems showed little differences in brightness.
2. Suspended solids, dissolved solids, and dissolved iron, copper, and manganese all increased as the white water system was closed. The increase in iron and copper were within tolerable limits regarding brightness, while the increase in manganese was excessive (2 p.p.m.), although manganese apparently has little effect on groundwood brightness, since brightness results showed little differences.
3. The use of sequestering agents for iron had little effect on brightness values, indicating that the iron present not in sufficient quantities to affect groundwood brightness.
4. The addition of appreciable quantities of manganese

Table II. Brightness Measurements

	Initial study				*Bleaching study*		*Study with known additions of manganese*		
	Distilled water	*SO_2 treatment*	*Oxalic acid treatment*	*Versen-OL treatment*	*Unbleached*	*Bleached*	*Distilled water*	*$MnSO_4$ water 2 p.p.m.*	*$MnSO_4$ 2 p.p.m. then washed*
Open System									
Initial tests	59.3	59.6	59.6	59.6	59.3	65.3	59.0	58.5	
Aging tests									
0 hr.	58.5	59.1	59.2	59.1	58.8	65.0	59.0	58.5	
4.5 hr.	56.7	57.7	58.1	57.8	57.0	62.5			
11 hr.	55.1	56.4	56.9	56.8	56.2	60.7			
24 hr.	53.9	55.2	55.7	56.0	54.9	58.8	55.0	54.5	
Closed System									
Initial tests	58.5	60.2	60.2	59.9	59.5	66.9	59.7	59.1	59.8
Aging tests									
0 hr.	58.1	59.9	59.2	59.5	59.6	66.9	59.7	59.1	59.8
4.5 hr.	56.5	57.8	58.0	58.2	57.8	64.8			
11 hr.	55.5	56.0	56.9	57.5	57.1	63.4			
24 hr.	54.6	54.1	55.9	56.5	55.9	61.7	55.5	54.6	55.5

sulfate to the samples had little effect on groundwood brightness, indicating again that manganese has little effect on groundwood brightness.

5. Handsheets subjected to an accelerated aging test of 24 hr. at 105°C. showed decreases in brightness of three to five points, but no significance could be established between the results of the different samples.

6. The pulp from the closed white water system showed a greater brightness increase upon bleaching and less brightness decrease upon aging than the pulp from the open white water system.

RECENT BOOKS

The Chemical Formulary. Vol. XI. Edited by H. Bennett. Reinhold Publishing Co., New York, 1961. Cloth, 6 × 9, 416 pages. $8.00.

Like the preceding ten volumes, the eleventh volume of "The Chemical Formulary" is of interest. Over the years it has been interesting to note the presence of this series of books on practical instructions; one might almost call them recipes in the technical libraries of industrial plants. Workers in research laboratories and general chemists in mills or factories have frequent need to known about formulations that may or may not relate directly to the work that they are doing. Very often a satisfactory answer appears in one of the Formularies. In browsing through any of the volumes a reader never knows what information will appear. The browsing is important since at a later date it may be very profitable to remember that something about the subject under consideration appeared in this book. It is the old story—just how can I put my finger on a scrap of information which is unlikely to be found in any of the formal texts.

On Fourdrinier Machine Wet Ends. Anon. Lockwood Trade Journal Co., 49 W. 45 St., New York, 1961. Paperbound, 6 × 9, 73 pages. $2.50.

A monograph covering the design and operation of paper machines from the stuff box to the couch. It is written for young engineers and technicians who are beginning a paper mill career without the benefit of a university training in paper technology and without aspirations to become a paper scientist. Among the subjects covered are the stock and white water system, slice and headbox designs, forming boards, table rolls, flat boxes, dandies. Two chapters deal with trouble-shooting and tracing paper defects to the wet end and curing them.

Pulp and Paper Chemistry and Chemical Technology. 2nd Ed. Vol. III. By James P. Casey. Interscience Publishers, New York, 1961. Cloth, 6 × 9, 862 pages with 113-page index. $29.50.

The final volume of Dr. Casey's series is a welcome addition to the literature of pulp and paper manufacture. The pagination runs continuously through the three volumes, ending with page 2113, followed by a 113-page subject and author index.

The final volume deals with paper testing and converting. Covered are chapters on properties of paper, use of statistics, pigment coating, printing, laminating and corrugating, saturation, plastic coatings, and resins.

Dr. Casey remarks that any technical book is likely to be out of date ten years after publication. Volume III reflects the author's statement "The greatest development over the past ten years has taken place in the areas of pulping, sheet formation and coating." He might have added the entire area of converting which appears to be moving ahead and will require a revision of the second edition of Volume III in another ten years or less.

Industrial Purchasing. 2nd Ed. By J. H. Westing and I. V. Fine. John Wiley & Sons Inc., New York, 1961. 534 pages. $9.50.

In the six years since "Industrial Purchasing" was first published, a procession of vital changes has affected the purchasing function. For one thing, the materials management concept of organization has expanded. In addition, industry has adopted various new practices to cope with the rising cost of transportation. Value analysis has gained in stature and become clarified in meaning. Quality and control procedures have been improved and are more widely accepted. Problems have developed in the fields of antitrust and administered pricings. More information has come to light on the subject of scrap disposal.

All of these developments, followed closely and appraised carefully over a period of timely J. H. Westing and I. V. Fine of the University of Wisconsin, are now incorporated into their second edition of "Industrial Purchasing." The book's authorship again includes members of the Milwaukee Association of Purchasing Agents, affiliated with the National Association of Purchasing Agents. In this way, academic and professional sources are able to combine the fruits of their studies and practical experiences.

The volume's fresh evaluation of buying for industry and budgetary institutions centers on policies rather than procedures, the approach found of such substantial use to those familiar with the first edition. The book now augments its discussion with 35 case studies designed to point up specific purchasing problems, as distinguished from broad cases that are nondirective in nature. Among other prominent features in the volume are chapters on commodities, and the attention given to government agencies and related institutions.

Encyclopedia of Chemical Technology. Second Supplement Volume. Edited by Raymond E. Kirk and Donald F. Othmer, Polytechnic Institute of Brooklyn. New York, 1960. Cloth, $7^1/_4 \times 10^1/_2$, 970 pages. $25.

The second supplement of the Encyclopedia, edited by Anthony Standen contains 59 articles dealing with subjects that have been particularly noteworthy. Cross references are made with the first supplement and the original 15 volumes. Among the topics covered in the second supplement are acetylene, boron compounds, ceramics, chemical coding, corrosion, epoxydation, laminated products, polypropylene, radioisotopes, thermodynamics, ultraviolet absorbers, and unsaturated polyester resins.

Polypropylene. By Theodore O. J. Kresser, Spencer Chemical Co., New York, 1960, Reinhold Publishing Co. Cloth, $5 \times 7^1/_4$, 268 pages. $6.50.

This book is the nineteenth in the Reinhold Plastics Application Series and is somewhat of a tribute to Professor Guillo Natta and his publications of the Montecatini Co. In the development of plastic materials there is often much concern over the existence, life, and extent of a

market. The author feels that polypropylene could fail to fulfill present expectations if closely related polyolefin materials, made by similar methods from olefins other than propylene, may be developed so rapidly that they might take away the markets predicted for polypropylene. The text covers the properties, chemistry, production and processing of polypropylene, packaging applications, and future developments.

Something Can Be Done About Paper and Board Finishing. Edited by John C. W. Evans, Paper Trade Journal New York, 1961, Lockwood Trade Journal Co. Paperbound, $8^1/_2 \times 11$, 80 pages. $2.50.

Twenty-seven articles covering various aspects of finishing problems which were published in the *Paper Trade Journal.*

Western Forest Industry: An Economic Outlook. By John A. Guthrie and George R. Armstrong, Baltimore, Md., The Johns Hopkins Press. 350 pages. $6.50.

This study of the forest products industries of the Pacific Slope, with projections to 1975, has just been published for Resources for the Future by The Johns Hopkins Press.

The area covered consists of the "11 western states" (Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming), the new state of Alaska, and the Canadian province of British Columbia. Principal industries dealt with are lumber, pulp and paper, and plywood and veneer.

These three industries, the authors point out, are growing rapidly on the Pacific Slope. In 1954 (the last year for which detailed Census figures were available) the United States portions of the area accounted for 56% of value added by manufacturing in the nation's lumber industry, 13% in pulp and paper, and 65% in plywood and veneer. The three industries in British Columbia have about the same relative importance in the Canadian economy.

"The future development of these industries is of considerable significance not only to the Pacific Slope area, but also to the rest of North America north of the Rio Grande, especially to the United States. The Pacific Slope contains the nation's last large stand of virgin timber, and the rate and manner in which this timber is cut will have strong impacts on forest industries in other parts of the country."

The authors trace the economic possibilities for western forest industries in the light of expected changes in population, technology, raw material supplies, location of markets, and competitive relations with other major producing regions, particularly the southern states. They also consider the implications of forest policy alternatives, of the concept of sustained yield, and of possible changes in management practices to meet future situations.

Mr. Guthrie is professor of economics and director of the Bureau of Economic and Business Research at Washington State University. Mr. Armstrong is research associate at the State University of New York College of Forestry at Syracuse University. Their research was supported by a grant from Resources for the Future to Washington State University.

The 350-page book includes charts and tables, and a 20 by 28 inch map in color of major forest types of the Pacific Slope. Priced at $6.50, it is available through booksellers or from The Johns Hopkins Press, Baltimore 18, Md.

EMPLOYMENT SERVICE

The rates per issue for Positions Open advertisements in *Tappi* are as follows:

Per line	$ 3
1/16-page Box	$ 50
1/8-page Box	$ 80
1/4-page Box	$125

Positions Wanted

E530-61. Chemical engineer, presently employed, B.S. in chemistry and chemical engineering. Twelve years of broad experience in R & D, mill technical control, trouble shooting, coating formulation, heat and light sensitive materials, office copying and duplicating papers. Record of accomplishments. Desires responsible position with a firm interested in office copy or a chemical company serving the paper industry. Résumé and references upon request.

E534-61. Chemical Engineer, M.S., 11 years experience in tall oil processes and production, trouble shooting, and research.

E535-61. Paper Engineer-Ph.D. in paper technology, age 33, desires position in research or in a capacity of rendering technical assistance to manager of manufacturing or converting. Six years' experience in Canada and Europe. Special interest: coating.

E536-61. Pulp mill superintendent or technical superintendent-bleached kraft. Ten years in control, research, and production.

Positions Open

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P2009-61. Man with background in paper mills or corrugated container plants to sell starches, dextrines, and related materials.

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(P2010-61)

RESEARCH AND DEVELOPMENT

Immediate opening for Research Engineer in the Pulp and Paper field. Degree in Chemical Engineering or Chemistry required, experience helpful. The person selected must have the initiative and ability to handle a project individually from beginning to end. All replies confidential. Reply to **Employment Office, OLIN Packaging Division, P. O. Box 488, West Monroe, Louisiana.**

(P2011-61)

CHEMICAL ENGINEER OR PULP AND PAPER SCHOOL GRADUATE

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Send résumé to:

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(P2012-61)

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A medium size newsprint mill, located close to major city in Province of Quebec requires a Chemical Engineer with several years of experience in pulp and/or paper mill operation. The work would involve investigations of present processes and systems of control and instrumentation for possible improement; the design and installation of additional process control equipment; the development, in conjunction with existing engineering and production staff, of improved methods of operations.

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(P2013-61)

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Write to P2014-61, *Tappi*, 360 Lexington Ave., New York 17, N. Y.

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Contact Mr. W. D. Stitt
BUCKMAN LABORATORIES, INC.
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(P2015-61)

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(P2016-61)

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Director of Research
West Virginia Pulp and Paper Co.
Luke, Maryland

(P2017-61)

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(P2018-61)

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Client company, a large, very successful, and continuously expanding fully integrated coarse specialty mill and converting operation in the South with branch plants throughout the U. S., in Canada and Europe, seeks an outstanding scientific administrator to understudy and in two years replace its incumbent Chief Chemist and Director of Research and Development, now 63.

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Make inquiry by duplicate letter to Mr. George M. Sunday personally in full confidence, enclosing two pictures and two copies of comprehensive résumé covering vital statistics; education; social, religious and professional affiliations; and chronological treatment of business background and experience, including present and past salaries. Telephone conference will follow, at which time cogent details will be revealed, descriptive literature forwarded and arrangements made for initial, exploratory interview with client principals.

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LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel, and Events

Delaware Valley

Speaking on the Beloit gloss calender, D. W. Ripley, of the Beloit Iron Works, Beloit, Wis., highlighted the January meeting of the Delaware Valley Section which was held Jan. 26, 1961.

Mr. Ripley reviewed the general area of surface finishing of paper and board products. He discussed the various degrees of smoothness and the character of the various resulting surface finishes. In this discussion, he touched upon the three classic mechanical means of surface finishing—the on-machine calender, the supercalender, and the Yankee drier.

He then introduced an entirely new concept in sheet finishing—the Beloit gloss calender. Mr. Ripley pointed out that the gloss calender provides an improved calendering method by use of the combined physical factors of pressure, heat, and friction. It was indicated that the Beloit gloss calender gives promise of producing equal or better finish to a given product while preserving bulk and strength.

Many intriguing possibilities were discussed for application of this device to printing papers, food boards, pretreatment and final finishing of coated papers and folding boxboards. It was also pointed out that the gloss calender provided for easier sheet handling and improved machine efficiencies.

March Meeting

The Fourth Annual 1961 Philadelphia Conference of the Graphic Arts held on March 17, 1961, in Philadelphia was an unqualified success.

Attended by well over 300 people, the all-day affair offered a diversified program dealing with numerous phases of the graphic arts industry.

Sponsored by the Delaware Valley Section of TAPPI, along with several graphic arts organizations located in the Philadelphia area, the conference consisted of a series of panel discussions aimed at airing many of the practical problems besetting the field of graphic arts.

The program, organized by a committee headed by M. M. Muntz, of P. H. Glatfelter Co., included papers and discussions on printing problems, recent developments in the industrial stages, printing evaluation, publishing problems, color engineering, binding problems, and future development in the graphic arts.

W. A. Rocad, Jr., M. M. Muntz, program chairman, and Al Saindon, Delaware Valley Section chairman, at the graphic arts conference dinner

With such a program, the conference progressed in its objectives of getting together the various factions of the graphic arts industry in open discussion of their mutual problems. The popularity of such an attempt is evidenced in the considerable interest already generated in the 1962 Conference.

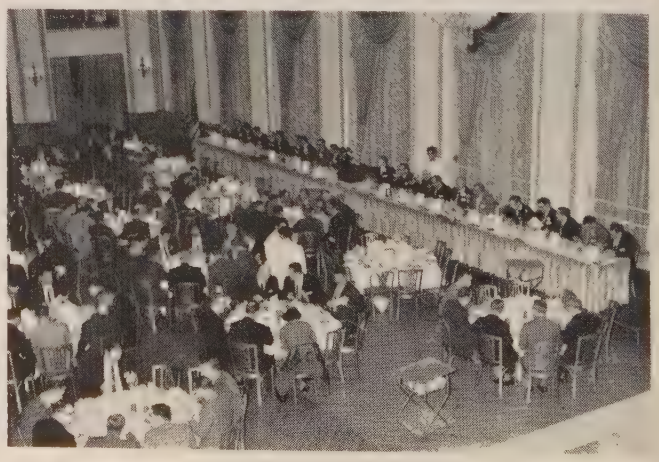
For the success of the 1961 Conference much credit goes to A. S. Erspamer of Scott Paper Co. who served as its general chairman and coordinated the entire effort.

April Meeting

The April meeting was held at the Engineers' Club on April 27. Announced at this meeting were the officers of the 1961–62 meeting year. The officers for 1961–62 will be:

Chairman: C. A. Wynn, Container Corp. of America, Philadelphia 27, Pa.
1st Vice-Chairman: H. L. Smaine, P. H. Glatfelter Co. Spring Grove, Pa.

The principal speaker Daniel B. Michie of the American Competitive Enterprise System, at the Philadelphia Conference of the Graphic Arts



A view of the graphic arts conference dinner

2nd Vice-Chairman: P. A. Cerasoli, Hamilton Paper Co., Miquon, Pa.
Treasurer: D. S. Blair, Monsanto Chemical Corp., Wilmington, Del.
Secretary: P. N. Yiannos, Scott Paper Co.

A feature of the meeting was a talk presented by S. T. Han, research associate, The Institute of Paper Chemistry. Mr. Han spoke on "A Simplified View of Sheet Formation."

PHILIP A. CERASOLI, *Secretary*

A Simplified View of Sheet Formation

S. T. Han

The formation of a sheet on a wire screen is a combination of two processes taking place simultaneously: the retention of fibers and the drainage of water. The theoretical aspects of these factors are discussed briefly.

THE topic of my talk tonight is "A Simplified View of Sheet Formation." I am rather hesitant to speak on this subject before a group of highly experienced papermakers. My discussion, however, will be largely oriented from the research point of view, and I shall try to demonstrate how the complex process of sheet formation may be simplified in order to gain some understanding of the nature of the process.

The formation of a sheet on a wire screen is a combination of two processes taking place simultaneously; these are the retention of fibers and the drainage of water. Until recently, the process of fiber retention has not been carefully studied. Ron Estridge, a former student at the Institute, considered the retention process to be governed primarily by probability and proved this to be true for an idealized system.

RETENTION OF FIBERS

Considering the retention of fibers we can plot the mass of fibers retained on a screen against the total mass of fibers approaching the screen. The slope of this curve represents the fraction or per cent of retention. This retention rate, α. is merely the average probability of retention for all kinds of fibers in the approaching suspension.

The probability that a fiber will be retained as it approaches the wire screen is dependent on a number of factors. The most important one is obviously the relative dimensions of the fiber with respect to the screen opening. The surface characteristics of the fiber, the structure of the screen, as well as the pattern of flow near the screen must also play their parts.

The two boundary conditions of the curve are of particular interest. At the very beginning, there is no fiber retained, but the initial rate of retention, α_0, is a finite quantity. This initial retention is of considerable importance to the formation of a very thin sheet such as tissue, which is only a few fibers thick. As the formation process proceeds, a complete retention will be reached sooner or later. This is indicated by the slope of unity. While this state of affairs is seldom reached in an actual papermaking process, it is deliberately attained in the laboratory studies of filtration in order to evaluate certain important fiber properties.

On the basis of the probability theory, Estridge evaluated the initial retention under highly idealized conditions. For a very dilute suspension of uniform and rigid fibers approaching a screen of parallel wires or square openings, he predicted the retention rate as a function of the relative fiber-screen dimensions. His experimental results for nylon fibers agreed very well with his predictions. To us in the research field, Estridge's work has provided a sound basis for further studies of retention. On the practical side, his theory can be of immediate use to screen operations which approach his stated conditions. He concluded that for fiber length classification, a square-mesh screen is more efficient than a rectangular one and that the reverse is true for the purpose of dirt removal. These conclusions by themselves are not surprising for they have long been utilized in practice. His important contribution is to establish the basic concept and quantitative relationships which can be used in the design and evaluation of screens. I expect that in the near future both screen operation and fiber classification will be considerably improved if the screen engineers can translate his theory into practice.

In sheet formation, however, we are more interested in the subsequent retention or the build-up of a mat. This is a much more complicated process and cannot yet be analyzed theoretically. Not only do we need to know how the geometry of the openings changes but also how this affects the retention probability. A description of changing geometry is very difficult because the fibers do not form uniformly over the entire area of the screen. By the nature of a random process where several fibers are initially deposited close together, the probability that succeeding fibers will be retained in that area becomes much greater than for the bare areas. The complete retention process can be treated at present only empirically.

Estridge suggested this relationship:

$$W_r + \frac{1}{k} \ln \frac{1 - (1 - \alpha_0)e^{-kW_r}}{\alpha_0} = W_t.$$

Here k is a constant related to the rate of change in geometry and retention probability. This equation can be transformed in terms of white water consistency:

$$S = S_0(1 - \alpha_0)e^{-kW_r}.$$

How well do these relationships describe an actual sheet-forming process? I have some evidence that for a vacuum former, the retention equation agreed with experimental data very well. These data were obtained in the laboratory for a sulfite pulp at an approach consistency of 0.3% and a final basis weight of 56 g. per sq. m.

DRAINAGE OF WATER

Next, we turn our attention to drainage, which governs the rate of sheet formation. This aspect has been intensively investigated in the last ten years. To be realistic we must treat the mat as a compressible material with variable fiber retention under changing pressure drop. If the flow is laminar through such a mat, we may develop a general equation for the time required to build up a mat of a certain basis weight such as this:

$$t_f = \mu \int_0^{W_f} \int_0^{W_r} \frac{r}{C\Delta P}\, dW dW_r$$

$$C = \frac{\rho(S_0 - S)}{1 - m_i S_0}$$

$$S = S_0(1 - \alpha_0)e^{-kW_r}$$

$$r = \frac{k_0 S_v^2 v^2 c}{(1 - VC)^3}$$

$$c = MP^N$$

$$S_v = f(W, W_r)$$

$$\Delta P = f(W, W_r)$$

It is obvious that to solve the first equation considerable information is required. From the research viewpoint, the question is how such information can be generalized in terms of elementary fiber properties and major operating variables. Our answer is that the present knowledge is still too fragmentary to give a satisfactory solution. Take fourdrinier operation as an example. The analysis of the table roll action by G. I. Taylor has greatly clarified the distribution of pressure drop along the nip.

S. T. HAN, Research Associate, The Institute of Paper Chemistry, Appleton, Wis.

We still have three major obstacles to overcome. The first one is the fines retention. We all realize that fines can slow down drainage because of their large surface area, but we do not know how fines are distributed in the mat. The second problem is the possible interaction between fibers and wire, causing much uncertainty in the evaluation of wire resistance. Finally, the hydraulic condition and flocculation factor are extremely complex and capricious; they have not been even taken into consideration in this treatment.

On the other hand, such studies have been applied to simpler situations and found to be quite useful. For example, my associate, W. Ingmanson, was once asked to locate the cause of frequent wet breaks for one of two apparently similar pulps. By measuring the filtration resistances of these pulps, he was able to conclude that the weaker pulp was due to its low specific volume. My own study of a vacuum former demonstrated that these equations can be simplified to determine the forming length and roof curve for design purposes:

$$L = \frac{\mu U \bar{R} W_r^2}{2\bar{C}\,\bar{\Delta P}}$$

$$\frac{H}{H_0} = 1 - \left(\frac{x}{L}\right)^{1/n}$$

MAT STRUCTURE AND STABILITY

The most important aspect of sheet formation is unfortunately the least understood one, i.e., the structure and stability of a wet mat, which determines the quality of the sheet. The structure of a fiber network can be described in terms of three factors: (1) the number of fiber centers, (2) the dimensions of fibers, and (3) the orientation of fibers. All these factors vary not only in a plane of the sheet but also in the direction of the sheet thickness. Therefore, we must know the distribution functions of these factors throughout the sheet. While these distribution functions are governed primarily by the laws of probability, they are also influenced by the operating conditions. A mathematical theory has just been developed by Van den Akker to relate the sheet strength to these distribution functions. His theory will be presented to the symposium on "The Formation and Structure of Paper" to be held in England in September of this year. While his theory deals with dry paper, the basic concepts can be applied to a wet mat equally well.

Since a wet mat in the process of sheet formation is continuously subjected to external forces, its responses to these forces which govern its stability are of important concern to us. Crudely speaking, the compressive strain induced by the fluid drag forces due to drainage is a stabilizing action because it tends to compress the mat and thus make it stronger. The shearing forces at the mat surface arising from the hydraulic conditions is a disruptive action which tends to reorient and remove the fibers from the mat. Since papermaking fibers are viscoelastic materials, the compressibility function previously shown must include the time effect. Harry Wilder has studied this aspect and found that creep and recovery behavior of a wet mat can be incorporated rather simply in the compressibility equation:

$$C - C_0 = (A + B \log t)P^N.$$

He estimated that this creep behavior can lower the drainage resistance as much as half on a fourdrinier machine as compared with laboratory filtration because of the extremely short duration of sheet formation at a table roll.

The wet mat is also subjected to shearing forces. Sheldon Kurath studied the response of a mat to cyclic shear. He found that the shear modulus can be represented by the concept of a complex number.

$$G^* = G_x + iG_y$$

$$C = M_x G_x^N = M_y G_y^N.$$

It is interesting to note that the shear moduli have the same functional form as compressibility. In fact, the exponent N has very nearly the same value for both cases. This is really not surprising because they are merely different manifestations of fiber and structural properties.

In conclusion, I wish to say that research in sheet formation has come to a maturing point, and we expect to see much greater progress in the near future. It is vitally important for the operating personnel in the industry to keep in close contact with research and to utilize the findings for practical problems. The progress of the paper industry depends on the fruitful applications of research, not on research alone.

Presented at the meeting of the Delaware Valley Section of TAPPI, held in Philadelphia, Pa., April 27, 1961.

Lake States

Lake States Section of TAPPI joined with the local ISA Section in arranging for the banquet held in conjunction with the National Symposium on Pulp and Paper Instrumentation in Green Bay. The meeting was held at the Northland Hotel on Thursday, May 11. There were approximately 200 people in attendance. Dr. Lincoln R. Thiesmeyer, president of the Pulp and Paper Research Institute of Canada, delivered the after-dinner address.

An account of the TAPPI-ISA meeting will be published in the August issue of *Tappi*.

Ohio (Indiana District)

The February Meeting of the Indiana District was held at the Marott Hotel in Indianapolis, Ind., Feb. 14, 1961. Completing the double-play on the subject of quality control started by Dr. Charles R. Hicks, Purdue University, at the joint meeting in January with the American Society of Quality Control the Indiana District offered a stimulating Panel Discussion "Quality Control in Practice" as the second part of the keystone combination.

Moderator: W. B. Lincoln, Jr., vice-president Research and Development, Inland Container Corp.
Panel Members: John E. Maphis, machine superintendent, Container Corp. of America, Wabash, Ind.
"Tests—Targets—Tolerances"; Keith Reichard, administrator quality control, R. R. Donnelley & Sons, Crawfordsville, Ind.
"Graphic Arts—Standards—Tolerances"; Harris O. Ware,

John Maphis, Machine Supt. Container Corp. of America, Wabash, Ind.
Keith Reichard, Administration Quality Control, R. R. Donnelley & Sons, Crawfordsville, Ind.
Charles Eberly, Chairman, Indiana District Paper Art Company
W. B. Lincoln, Jr., Inland Container Corporation, Panel Moderator
H. O. Ware, Technical Manager, The Beveridge Paper Company

technical manager, The Beveridge Paper Co., "Practical Application—Statistics—Results."

Tests—Targets—Tolerances

John E. Maphis

A running description is given of the quality control program at the Wabash, Ind., plant of the Container Corp. of America.

I HAVE been asked to explain the details of our quality control program, noting particularly the tests run, the equipment used, and the sources of specifications. At Wabash we operate two cylinder board machines producing about 180 tons per day primarily of bleaches, patent coats, machine clay coated, and kraft backs of these grades.

In covering the points of quality control in our manufacturing process you will note that almost all of our production people are responsible in one way or another for some phase of quality. This stems partly from the fact that we have only three men per shift, split between the two machines, who are responsible for nothing but quality and partly from our belief that a high grade product cannot be produced unless every man in the mill is quality oriented.

Our quality program begins in our Raw Stock Department. Incoming pulp is tested by the main laboratory for burst, tear, brightness, dirt count, beating time, and pH. The testing procedure is basically TAPPI's with C. C. of A. specifications. Any pulp which is badly out of range in any of the aforementioned properties is segregated and used in such a manner that the defect does not hurt our finished product.

Wastepapers are inspected by our raw stock foremen as they are received and excessive foreign materials or improper fibers will cause the shipment to be rejected outright or downgraded to its proper level. The "Paper Stock Standards" published by the Paper Stock Institute are used to evaluate waste papers. If wet strength is suspected, a sample is brought to the laboratory for testing.

In the beater room each man feeding a tub or beater is expected to sort the stock he is furnishing. This is desirable on all wastepapers and especially the higher grades used in top liners and underliners. Handsheets are made of each top liner beater in an attempt to catch dirt, etc., before the stock hits the paper machine.

Freenesses are taken at three points in the beater room. Canadian Standard freeness testers are used, and specifications are set up by the Production Department. We attempt to hold all four liners within a 20-pt. range. Specifications accompany each order for freeness of the top liner after refining and at the machine highbox, and for underliner, filler, and bottom liner at the machine highbox. The top linerman is responsible for the freeness at the refiner and he takes the test himself. A lab man checks the freenesses at the highbox. The jordan man also checks the liner freeness at the jordan.

Moving on to the paper machine itself, the machine tender is responsible for his quality in general and the supervsion of his entire crew.

The felt checker is responsible for checking the pH of the vats. He does this with a Taylor pH slide comparator. Specifications are set up by the Production Department.

The back tender has several quality duties in addition to supervising the dry end of the machine. Included are moisture, checked with a Hart moisture meter and run to Production Department specifications; weight, Toledo scales using industry specifications; caliper, checked with a Cady dead weight micrometer, run to industry and Production Department specs; and curl, checked visually and run to production department specs.

The finisher, in addition to his normal duties, is responsible for initiating and partially filling out a combination check list and loading tally which remains on each skid until it is shipped. When the finisher signs this ticket he is saying that by visual inspection this skid has no fuzzy knife or slitter edges, no folded or torn sheets, no trim or scrap in the load, no curl or warp, and that the sheets are square and of the correct width and length.

Two cutter boys act as inspectors at all times and are responsible for throwing out slime spots, mash spots, dirty sheets, streaks, etc.

In addition to our human inspection, our machines are equipped with two mechanical inspectors. We have automatic Hurletron caliper controls which were installed partially to improve quality and partially for improvement in efficiency of operation. We also have automatic Foxboro moisture controllers which were installed solely to improve the quality and uniformity of our products.

We maintain a chartroom operated by the laboratory at the dry end of the machines for physical testing.

All orders are tested for the following:

1. Caliper—Cady dead weight—production specs.
2. Weight—Cady scales—industry specs.
3. Sheet size—steel rule—industry and customer specs.
4. Moisture—Hart meter—production specs.

In addition, any or all of the following will be run on specific grades or orders.

1. Bender—C.C.A. press—production specs.
2. Mullen—Perkins—customer specs.
3. Tear—Elmendorf—customer specs.
4. Stiffness—Taber or Gurley—customer specs.
5. Vanceometer—Hillside—production specs.
6. Proof print—flat or gloss—Vandercook press—production specs.
7. Proof print—tack resistance—Vandercook press—producduction specs.
8. Water drops—various methods—customer specs.
9. Immersion—TAPPI—customer specs.
10. Surface water resistance—Cobb—Abrams—customer specs.
11. Curl—Taber—production or customer specs.
12. Internal bond—various—production specs.

After each set of tests is taken, the chartroom man records all tests on a master chart which is kept daily for each machine. He also records all tests on a small slip of paper which he immediately hands to the back tender. The back tender is then responsible for making any changes which might be necessary and passing the slip along to the machine tender. In certain specific cases, such as an extremely bad bender, the chartroom man will locate and notify the tour boss in order to speed up corrective action.

After the skid leaves the machine it is wrapped and banded by a board mill finisher. This man rechecks the skid for bad edges, curl, scrap, folded sheets, etc., and in addition, vacuums the edges to remove slitter dust, etc., which may still be present. After completing this job he signs the combination checklist-loading tally.

When the skid is loaded on a truck or railroad car, the loader checks for torn wrappers and loose or broken bands. He also signs the checklist tally.

Rounding out our production quality control are the tour boss and shift technician. The tour boss has obvious quality responsibilities. The shift technician is unique with our mill, however, and I will explain his job more fully. In many ways he is an assistant tour boss but instead of reporting to the mill superintendent he is a lab man reporting to the technical superintendent. His primary responsibilities are color, brightness, gloss ink treatments, coating, and supervision of shift lab men. He has authority to change furnishes and chemicals to obtain desired results. To check and maintain color, he has at his disposal a Gardner color difference

JOHN E. MAPHIS, Machine Superintendent, Container Corp. of America, Wabash, Ind.

meter, a G.E. brightness tester, a MacBeth Lablite, and a MacBeth Examolite. For checking brightness he uses the G.E., Gardner, or a Photovolt.

Board which is held for quality reasons is rechecked by the lab each morning. Based on these rechecks, and sometimes consultation with sales, the decision is made to ship or remake by the technical superintendent and mill superintendent. If disagreement occurs here the decision is made by the plant manager.

When complaints are received from customers, a lab recheck is run and the technical superintendent issues a written report to sales on the cause of the problem and what steps have been taken to prevent a recurrence. On some types of problems the manufacturing crew involved is notified of the defect and what problems it caused our customer.

Records are kept of each complaint, whether serious or not, and quarterly reports are issued on total numbers of each type of problem. These reports are used to spot trouble areas in manufacturing or crew performance.

Weekly meetings are held with machine and beater room crews to discuss complaints and discuss methods of improvement. We have always stressed at these meetings that a uniform product is often more important than meeting some specifications. These meetings generally last from 30 to 45 min. and the men receive straight time pay for the duration of the meeting. Attendance is "semivoluntary."

We have also secured movies from machinery manufacturers showing various types of printing presses. We have used these to show our men specifically how various board defects cause the carton plant problems.

In order to assure our customers of a uniform product from run to run, we maintain a furnish card file on all orders and a machine specification card file.

A discussion of quality would not be complete without mentioning both our Maintenance Department and Sales Department. Our maintenance people are made fully aware of quality problems relating to machinery as well as tonnage and operational problems.

Our Sales Department is extremely important because even if our product were the best available (which we firmly believe) we would have trouble selling it if it were not delivered on time, in the quantities and sizes ordered, and if customers' needs were not serviced and evaluated promptly and courteously.

Presented at the meeting of the Indiana District of the Ohio Section, held in Indianapolis, Ind., Feb. 14, 1961.

Quality Control in Practice

H. O. Ware

Quality control is concerned with the magnitude of product characteristics, product uniformity, and product cost and the variables of the process by which the product is made. These factors are discussed generally as they pertain to the development of specifications and their application.

When the first businessman received his first complaint from a customer, he must have begun to think in terms of quality control. When technical people began coming into the paper industry to perform the quality control function, the emphasis was on the prevention of defective manufacture. In many people's thinking, quality control is still concerned primarily with the prevention of defects. Quality control has grown considerably in stature in the paper industry since about 1925. In its broader sense, quality control is now concerned with three features of a product and all the variables of the process by which the product is made. The three product features are the level or magnitude of individual quality characteristics, the product uniformity of individual quality characteristics, and the best cost for achieving both level and uniformity. It is not acceptable quality control to achieve high quality level and a high degree of uniformity at an excessive cost. It is likewise not acceptable to make the cheapest, low cost product with an unacceptable level of quality and an intolerable degree of uniformity. It is likewise equally unsatisfactory to overbuild a product for its intended end-use unless lowering the quality provides no opportunity for cost savings.

H. O. Ware, Technical Manager, The Beveridge Paper Co., Indianapolis, Ind.

Now that we have reviewed briefly the scope of quality control, it might be well to distinguish between a quality record and quality control. In the early years when I first traveled about the paper industry, it was not uncommon to find a paper mill which tested its paper products and called it quality control. But many did the quality testing in a central laboratory some days after the product had been manufactured. I recall a discussion with a paper mill chemist who had just evaluated a customer complaint on picking and who said, "Our records show that the wax was low on the order and sure enough we got a picking complaint." The data which indicated that the wax was low were not available to the machine tenders at the time the order was being run nor had the technical department offered to the operating department a suggested corrective measure which could be immediately applied when this situation arose. A good quality control system, if it is to provide control and not be a data historical society, must detect quality level, variations in quality level, and variation in important correlating process variables, and bring this information to bear on the process at the time the variation occurs. This was the next step which occurred in the evolution of our present quality control systems. Laboratories and test stations were moved out into the mill and the tests were performed and reported to the machine operators while the product was being manufactured.

In spite of the fact that these evolutionary steps occurred, customer complaints continued to exist no matter how diligently a great mass of data was reported. Progress came slowly and the more visionary people responsible for quality control started to seek out new tools and new techniques which would be more effective and provide better assurance that the products manufactured would find acceptance in the market place. Thus entered a new tool called statistical quality control. It is the current quality control frontier.

Statistical quality control is a branch of mathematics devoted to probability. It was first applied in the biological sciences and specifically with respect to the calculation of life insurance premiums. Here it was desired to know that you would probably live until all of the premiums were paid.

Statistics have three points in their favor for quality control. *First*, the arithmetic gives a measured dimension to data compared to the alternative of a qualitative estimate. Perhaps the meaning of this statement would be clearer to you if we take the example of a hundred basis weight determinations made on 100 successive sets of paper from a paper machine. We might each scan these data and give our opinion of the average, the simplest statistic to be derived from the data. In your judgment the average basis weight might be 90 pounds and in my judgment, the average basis weight might be 95 pounds and the actual average, if we made the arithmetic calculations, might be 85 pounds. In the first two cases, we have a qualitative estimate of the average and in the latter case we have a calculated estimate of the average. I am sure we all recognize the calculated average is the better. Similarly, statistics can be used to quantitatively estimate uniformity, correlation, source of variation, and significance. The *second* important point in support of statistics is its use to get "a measured estimate of the capacity of the process to reproduce itself." This might also be stated another way which would be, "a measured estimate of the probability that the paper machine can come within gunshot of a specification all day." It is in this latter estimate that the theory gets a

little sticky and the practice may require specialized techniques that are in the province of the statistician. The *third* point of justification for the statistical approach is that the statistical technique requires and cultivates a certain discipline in logical thinking about product quality. Instead of a bunch of empirical generalities, statistics requires that you define specifically what is of concern with a specific characteristic. Is it the average, or range, or variance that must be calculated and evaluated.

One of the major problems which must be overcome in any good quality control system is resistance by both the operators and management to techniques which are not understood by them. It is of paramount importance that the methods be accepted and used by the people who are manufacturing the product. It is on the basis of the foregoing evolution of quality control systems that your program committee in Indiana TAPPI decided to "double play" the subject of quality control with two meetings. At the first meeting, Professor Charles Hicks, a man with long experience in the field of quality control and statistical techniques, outlined what he felt were ten commandments for statistical quality control applications. Dr. Hicks' ten rules reflect his experiences in this field and are more than worth repeating here:

1. Grease the squeaky wheel.
2. Begin at the end.
3. Train as you go.
4. Don't overorganize.
5. Study the sources of variation.
6. Keep the statistics simple.
7. Quality control men must show genuine interest in the problem.
8. Plan the experiment first.
9. Report the results in understandable language.
10. Put a dollar sign on your work.

It is a known fact that in the nature of things, duplication is not exact. Whenever an act is repeated it is done a little differently. As a paper machine makes paper it makes it a little differently each succeeding inch down the machine and each succeeding inch across the machine. In all of the work that we do, we depend upon the properties of the statiticians fundamental tool, the frequency distribution curve.

By way of an example, I have taken the basis weight data from a run of bristol board which we produced. Individual blocks have been prepared representing each basis weight determination which was made during half the mill run. All of the blocks which are blue represent those basis weights which are within 4 lb. of the standard. All of those blocks which are yellow are for basis weights which are between 4 and 8 lb. of the standard. The blocks which are red are more than 8 lb. from the standard. When these blocks are assembled, they form a pyramid which resembles a frequency distribution curve. The blocks indicate that if we reach into the mill run and grab at random, the greatest chance is that we will get a blue block or a weight within 4 lb. or less of the standard. The actual chance that we will get a blue block is two out of three. The chance that we will get a red block or a weight more than 8 lb. away from the weight standard is one chance in 20. If these same data were presented graphically rather than with blocks, we would find that they distribute themselves around the average as the normal frequency distribution curve. For the purpose of this meeting tonight, the pertinent properties of this curve are the mean, the standard deviation, and the 2-sigma limit.

The mean is the arithmetic average. In plain English it is a quantitative estimate of only the gross level of the quality. It does not tell us if we have good or poor quality. It tells us nothing about the individual units making up the average. Some of these units may be very good or very bad. A stable paper machine and an erratic paper machine may make paper and average the same basis weight but the stable machine would produce much more paper closer to the average, its dispersion about the average would be better. It, therefore, follows that our estimate of quality must include a quantitative estimate of dispersion. This can be done by the calculation of standard deviation or little sigma. Reference to a normal frequency distribution curve will demonstrate a way by which the quantitative estimate of dispersion can be handled. It is important to observe that the horizontal or X axis represents a scale of size or degree of a property. The vertical or Y axis represents the count or frequency of occurrence of the sizes along the horizontal axis. In this kind of a plot the area under the curve or the area under any portion of it is the significant thing we want to read or estimate. An arithmetic characteristic of the frequency distribution curve is that the root mean square of all values define the 68% of area around the mean. This permits us to use simple arithmetic to calculate the uniformity of test values. This root mean square is known as standard deviation. The lower the standard deviation, the more uniform are the test values about the mean.

Thus far we have established two distinctive measures by which quality may be defined. With some modification these measures can be used to state a specification for a property of a product in sensible terms. At this point we arrive at a second milestone and are in conflict with our Sales Department. They want not only the average to be higher than the competitor's but also the standard deviation to be zero. They insist that it has always been that way when business was good.

A specification is a way of defining what is wanted in a product. It is also true that for economic reasons the specification must resemble something that the process can produce most of the time. When this is not true either the specification must be changed, the process must be changed, or the price must be changed, no more, no less. It, therefore, becomes important to known something about the "capacity of the process to achieve a quality level and reproduce itself at that quality level." This might be stated as the total dispersion about the mean or some major portion of the dispersion about the mean. Without dwelling upon the various reasons for doing so, we employ 2-sigma limits, i.e., two standard deviations about the mean, to characterize our process and as a basis for specification sheets.

These limits include about 95% (95.45%) of the area under the normal frequency distribution curve. When the frequency distribution curve is rotated 90° and the mean, standard deviation, and 2-sigma limit lines are extended, we have the elements of a control chart. Now the coordinates become test level on the y axis and time on the X axis. A literal interpretation of this chart might be, on the basis of past performance this process can make this grade of paper within the upper and lower control limits and if the tests go outside these limits *action* is needed by the operators to bring the tests back toward the mean.

The Beveridge Paper Co. has a quality control program. Our quality control laboratories are located in the plant. They do report promptly to the operators the results of the tests. We employ some of the simpler statistical techniques in arriving at our specifications and our quality control charts. In some cases we employ additional statistical techniques for the purpose of correlation, determining variance, assignable cause, and to test the significance of data.

Some of the specifics are as follows:

Past performance is analyzed for mean and standard deviation for the past 100 pieces of data on each specific property on each specific grade. This serves as basic data. A standard work sheet is used so that the function is clerical.

At the management level, participated in by sales, operations, and technical, the standards for the grade are agreed upon. A specification sheet is prepared. The specification sheet contains:

1. The basic data for mean and standard deviation, i.e., the recent past performance on the grade.
2. The agreed upon standard.

3. A specification limit obtained by applying 2-Sigma or 3-Sigma limits from the basic data to the standard.

4. When a new test is added to the standard but on which no past performance is available, the specification limits are left open until the data are available.

5. Finally, the specification sheet is authorized by signature for sales, production, and technical. This authorization is important and when so done says by inference that sales has agreed they can sell it, production can make it, and technical can evaluate it. Here a little give and take is necessary and some special situations arise which require judgment. By and large, it works well.

Testing is carried on in a control laboratory by periodically sampling the finished product from the paper machine and running the usual quality control tests and some testing of the process variables. Basis weight, caliper, and moisture is run on everything. Dennison wax, K & N ink, and smoothness is determined on all printing grades. Brightness, sizing, and physical tests are made when pertinent. Visual inspection of all grades for appearance, color, and defects is done in comparison with an approved standard sample. In some cases, we have standard "no go" samples established from customer complaints. The frequency of testing is determined by work load rather than by statistical design.

The reporting of results is carried out as follows. Two reports are made in the control laboratory. One is graphically done on a control chart where the limits from the specification sheet serve as the y axis scale. This control chart is used by supervisory personnel during the running of an order and by sales for review the following day. The other report is made numerically on a ledger sheet for the grade. This latter sheet is used as the data source for revising specification sheets. A third numerical report is made on a log maintained at the paper machine for the operators.

All values within specification limits are posted in green and all values outside specification limits are posted in red. We generally use 2-sigma limits and it is presumed that 5% of our tests will be outside the specification limits. The question naturally arises, "Is this material outside the limits defective and can it be shipped?" The answer is that it may require special attention. Where it has been established that the capacity of the process to reproduce itself is poorer than the customer's specification limits, the control tester is instructed to circle the test on his reports with yellow pencil and to place a yellow "no go" ticket in the set or load of production. This item is then reviewed for retesting, rejecting to broke, offered for sale as seconds, specially assigned, or shipped.

Something should be said about the value of quality control to a company. In considering the results from quality control we must be careful to distinquish between the quality control's function of indicating a *need for action* and the development or operating function of *taking the action* on the process or the product. In this respect a quality control function in a company is something like a newspaper in a community, it collects, reports, and interprets the facts but it hadn't better make them. On this basis quality control must be evaluated by whether it made the facts available. A good end result depends upon both bringing facts to light and proper utilization. Our quality control program claims the following specific results:

1. Preparation and the contemporary revision of about 250 specification sheets.

2. Reporting the level of quality around the clock when the process is operating. It has indicated many areas where the level was below that desired and where the process could not achieve a higher level. A basic change in process was thus required. In those cases where process changes have been made new levels have been attained and measured.

3. Uniformity has been improved. A case in point is basis weight, caliper, and moisture control. Using the ratio of variance before and after quality control charting as a criteria, the variation in basis weight was reduced to 21% of past performance, caliper to 17% of past performance, and moisture to 50% of past performance. It should be pointed out here that the reduction in variation of basis weight, caliper, and moisture were achieved in about six months without any major changes in equipment or raw materials. It is, therefore, apparent that this reduction in standard deviation, that is the increase in uniformity, must be attributed to people and the educational process that is continually in progress when quality control systems are in operation. In my judgment a good quality control program can be justified on this basis alone, but it must teach.

4. Quality control has indicated the possibility of and evaluated the results of cost saving changes in the process, helped improve relations with critical customers, opened the door to new business and altered our customer complaint pattern. Examples in each of these areas I am sure are familiar to all of you and further examples will not be given.

Although Dr. Charles Hicks recommends that we put a dollar sign on statistical quality control work, and I will agree it is a good convincer, there are times when the calculation of the dollar value of such work would take too much time. There are other cases where an estimate of dollar value would not be as high as the real value. As a case in point, "What is a company reputation worth in dollars if the competitor has a lower price." It cannot be argued that it has no value. The same is true with a good quality control program. How do you handle the question, "How much business do we have now that we would not have if we didn't have a quality control system?" Some items may be definite, but many are not. With a good quality program an organization is far more flexible in meeting competitive situations. Among other reasons, communication and understanding between the operators, the supervisors, sales, customers, and management is better. Problems are better defined, confidence is higher, teamwork is better. And what would you pay extra for sales confidence?

Perhaps we can conclude that a good quality control program is a dynamic part of a vigorous company. It cuts across all the lines of company activity. It measures, records, and evaluates. It also strongly promotes confidence, education, and communication.

Presented at the meeting of the Indiana District of the Ohio Section, held in Indianapolis, Ind., Feb. 14, 1961.

Moderator's Summary of Panel Discussion

The speakers this evening have given us much food for thought. Harris Ware did an excellent job of outlining the philosophy, technical significance of the statistical approach, and the worth-while results which may be achieved through the practical application of modern quality control techniques.

He taught us that in its fullest scope, quality is not just prevention of defective product or sorting out the scrap.

It controls the level of a variable characteristic of the product.

It controls and measures the uniformity of such characteristics.

Finally, it aids in controlling the cost of achieving both satisfactory level and uniformity.

It was emphasized that the quality control frontier is based on the statistical determination of probabilities which leads to the very important conclusion that "For economic reasons, the specification must resemble something the process can produce most of the time." This is an extremely important fundamental for everyone concerned with specifications and/or quality control to consider at all times.

Specific illustrations in Mr. Ware's description of the Beveridge quality control program gave convincing evidence worth-while results can be achieved through such a program.

John Maphis covered in detail the many points in the mill requiring attention from the quality control standpoint. Each of these locations has its own individual problems. He also discussed the test equipment and procedures which

were used at each location to assure production of acceptable quality finished product.

One important point brought out was the source of each of the many different standards used on raw material and product.

Details of the program were described bringing out the importance of each man contributing to the process. It was emphasized that you *make* good quality and do not inspect it into the product or just suddenly find it at the end of the process.

It was pointed out that frequently uniformity of quality characteristics are often of much greater importance to the satisfactory use of board than is specific adherence to a given test level. Many of the operations in the customer's plant, such as printing and scoring, can be seriously affected by wide variations in quality whereas they are not seriously affected by even substandard level of quality. It is very desirable that the relative importance of these factors be given their proper level of consideration.

Mr. Reichard described a relatively new quality control installation. Involved first was the establishment of a Quality Standards Section. It was interesting to note that their program obviously satisfied the ten commandments for quality control presented by Dr. Hicks. They definitely greased the squeaky wheel and did not try to work on the entire plant at one time. Emphasizing their philosophy that quality was the result of skills and attitudes of men who do the work, plus materials and processes, great care was taken to communicate objectives and details of the program to workers. The talk stressed the facts that you must know what your customer wants and meet his standards. It is only possible to guarantee uniformity by having established an objective standard which all craftsmen on multiple shifts can duplicate. It was emphasized that while standards should be realistic they should also be challenging since the quality attitude of the craftsman will be improved through this contact with the quality analyst. It was pointed out that the analyst with a fine quality concept and knowledge of machine and material limitations was in an excellent position to furnish instructions that would encourage good quality at the start of the job.

Donnelley's second move, according to Mr. Reichard, was the installation of an inspection section. Inspectors were accountable to the administrator of quality control, operated on the basis of objective evaluations only, making use of established standards. In other words, exactly the same objective standard was furnished for the craftsman and the inspector so that both were measuring with the same tolerance schedules and tools.

It was emphasized that inspection records to document the quality of the job and to provide evidence of trouble patterns were established but that care was exercised that inspection frequency did not suffer as a result of excessive clerical duties. The inspector's prime job is to keep the line supervisor informed of the quality of work being produced so that improvement action could result when needed. Quality control reports to top management and the line organization cannot ship product that has not been approved by Inspectors.

Donnelley's experience has indicated the desirability of starting with a pilot operation and avoiding any semblance of a crash program. If objectives and standards, tolerance schedules, and measuring tools are reviewed with the line foreman and the craftsman, before the program is started in any area, success is very likely to follow. Failure to communicate and introduce the program adequately can result in misunderstandings, resistance, and lack of cooperation that may destroy the entire program.

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What's New in Drying

J. A. Villalobos and R. C. Gillette

This paper is concerned with the practical aspects of design and application of high velocity driers and floaters. Mention is made of the Dryector and the Moist-Selector which are recent developments for the drying of paper on the paper machine.

The term, "drying" refers generally to the removal of moisture from a substance. In fact, moisture is so frequently water and the gas so frequently air that this combination will provide the basis for most of the following discussion. It is important to emphasize, however, that the equipment, techniques, and relationships are equally applicable to other systems as well.

There are two basic concepts that rule the drying operation, when applied to a practical case:

1. The means of achieving the mass and heat transfer operation. The manner in which water or solvent is removed from the goods is tied in directly with the manner in which heat transfer is supplied to the goods within the drier.
2. The other aspect of the drying operation is the handling of the goods. This part of the operation is mechanical. This discussion of the new developments in the field of drying will cover both aspects of the drying operation.

HIGH VELOCITY DRYING

High velocity drying is probably the most important new development in the field of drying. The statement that high velocity is a new development is questionable, but its importance stems from the fact that it has grown into a wide variety of applications. It is used not only in drying but also in curing, heating, cooling, and other industrial applications where heat is transferred, to heat or cool material at a very rapid rate.

There has been a considerable amount of literature published recently on the academic aspects of high velocity drying. Therefore, I am not going to spend much time on the fine aspects of the heat transfer coefficient correlation which rules the high velocity drying principle instead, I am going to concentrate on the practical aspects of high velocity drier design and its applications. However, I feel it will be useful to give some kind of basic background so that some of the concepts will be better understood.

How is the drying achieved? In order to remove water out of a solid material, example paper, it is necessary to supply the goods with heat—B.t.u. The water is not going to come out of the solid unless the right amount of heat is applied to it, which in turn will be used by the material to evaporate the water. It is well known that it takes, under certain conditions, approximately 1000 B.t.u. per lb. to evaporate 1 lb. of water. It is then quite clear that the rate at which heat is supplied to the material has some relationship to the amount of moisture or water that is going to be removed from the material. It is for this reason that drying is indirectly studied by means of the heat transfer. The basic equation that controls the drying operation (from a heat transfer aspect) will be:

$$q = h \times A \times (T_A - Ts)$$

where q is equal to the B.t.u. per hour per square foot applied to the goods; h is equal to the film coefficient in B.t.u. per hour per square foot per °F. and ΔT equal to the temperature of the air minus the temperature of the material under drying.

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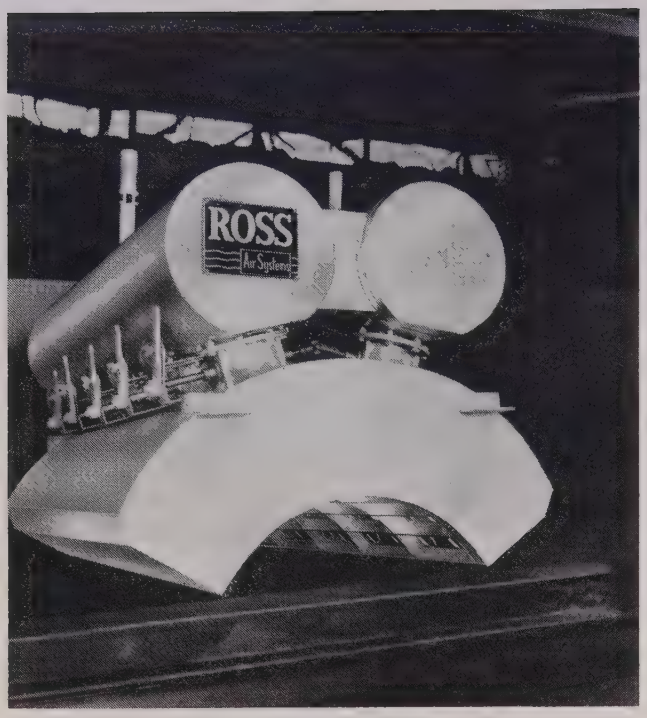

Fig. 1

From this equation, we see then that there are two important aspects of the drying process: (1) the heat transfer film coefficient = h and (2) the ΔT, or the temperature difference between the drying medium and the goods.

Therefore, drying can be controlled in two ways: By the temperature of the air used in the drying process and by controlling the design parameters of the drier which controls the film coefficient h. In any of the convection driers the film coefficient h depends on the combination of the following factors: (1) the nozzle design, (2) the air velocity, and (3) the nozzle spacing.

In the design of high velocity driers, the given variables are arranged so as to give an optimum h factor. This does not mean necessarily that the h factor is designed to be an absolute maximum, but that h factor is selected to be the optimum value in balance with good practical considerations. Let's analyze the design factors and how they effect the drying.

Nozzle Design

The nozzle design varies with every application, however, for high velocity driers the nozzle must be selected to accomplish two things. It must discharge a clean air knife so that the air core will remain in motion with a minimum of loss in air velocity. In other words, it must discharge the air velocity as far as possible. Secondly, the pressure losses across the orifice must be kept low to obtain the highest velocity with a given static pressure at the drier header.

There are several type of orifices that will fulfill the requirements given above. From practical experience, using a large number of different types of perforations in actual field use, a two dimensional convergent nozzle proved best. One of the strongest reasons for selecting a two-dimensional nozzle as it is shown in Fig. 1 is the fact that the air application across the goods is continuous. This is not the case with the round holes or any other type of perforation which will not allow the air to be applied continuously across the trim of the paper. At high air velocities, with corresponding high drying rates, the uneven air application has a tendency to streak the goods and also to show a certain amount of uneven shrinkage or cockle. Another important practical asset of two-dimensional convergent nozzles is the fact that it can be equipped with excellent exhaust relief. As shown in Fig. 1, the spent air is removed from the point of application by means of the channel space between the nozzles and then taken to the return chamber by means of the return tubes. This means the exhaust air will not interfere with the drying of the goods, as would be the case if the exhaust air had to return between the nozzles to the edges of the paper. If the goods are narrow, this is not too critical, but as the width of the drier increases, this factor becomes more and more important.

Another important aspect of nozzle design is the presence of the exhaust ports at a good distance from the material. It is possible to design an air drier which presents a smooth surface. However, it would be necessary to place the ports very close to the goods. As it has been observed in practice, the exhaust ports present a strong suction effect over the goods, creating problems in operation, since once the paper is lifted from the drier, it will create a break. Also, by exerting a suction pressure over the goods, it will create an uneven drying condition which shows, sometimes quite clearly, on the finished product.

Air Velocity

In a drier, the real variable is the air velocity. We know that it is possible to change the temperature of the air, which is one of the variables that affect the drying process. The other possibility would be to change the air velocity, since the air nozzle design, nozzle spacing, size of nozzles, etc., are already fixed by specification. The air velocity can be changed in two ways: (1) by controlling the air volume to the drier header. This is normally done by means of dampers in the duct work or by changing the speed of the fan, and (2) by changing the distance between the nozzle outlet and the goods.

This is the reason why it is important, when we talk of high velocity drying, to be conscious of the distance between the nozzle and the goods. It is important to have the correct relationship between the nozzle opening, and the distance between the nozzle and the goods in order to achieve the maximum drying effect. It must also be clear that increasing the distance between the nozzle and the goods in order to control the velocity at the impact point, is not an efficient way to control the drying. The horsepower input to the drier will remain constant, but the drying will decrease. It would be more efficient to control the drier by volume control since this method will decrease the horsepower consumption. It is for this reason, that most of the high velocity driers have vortex dampers at the supply fan, so that the air volume can be controlled at a maximum efficiency.

It must be emphasized that a close relationship exists between higher velocities at the outlet of the nozzles and the distance between the nozzles and the goods. This is important because, especially in the converting field, you hear certain statements made about drying equipment. Some people think they have a high velocity drier, but a closer inspection of the unit reveals distances between the nozzles and the web in a range of 3 to 6 in. Obviously, equal or higher drying rates can be achieved with lower air velocities and closer distances between the goods and the nozzles. A design such as this only increases the initial cost of the unit and wastes the customer's money, since the operating cost will be considerably higher.

Nozzle Spacing

The nozzle spacing has an important bearing on the coefficient of heat transfer. Generally, the closer the nozzles are to each other, the higher the coefficient of heat transfer. However, as was pointed out in the previous paragraph, the necessity of providing good exhaust conditions to the air drier prevents a design with very close nozzles. In high velocity driers used for paper machines, the widths are normally over 100 in. wide and it is then necessary to provide at all times good exhaust conditions. Therefore, the nozzle spacing for this type of nozzle design is a compromise between high drying and good air distribution.

High velocity started in the paper industry for increased drying in the paper machine. Today this function still remains but high velocity also has been used very successfully to correct the moisture profile across the trim of the paper. From this beginning in the paper industry, high velocity has spread to the converting field for the drying of coatings and other drying and curing processes.

HIGH VELOCITY FLOATERS

A floater is by definition an air drier in which the material is supported and carried through the drier by the same air that is effecting the drying process. In this type of equipment the supporting and carrying of the web is not done by mechanical means, as is the case of driers with conveyors or rolls, but it is done with air. This type of drier has the greatest application for those materials which cannot touch any solid surface until it is pretty well dried or completely dried. In many of the applications, the weblike material leaves the coater, goes through the drier and is wound at the reel without touching any solid surface during the drying cycle.

Originally floaters were used in the coating industry to dry one-side coated papers. Then, in most of the applications, the air was only applied from the bottom side of the web. The velocities were normally very low and the tunnels quite long for reasonable web speeds. With the advent of high velocity, development work was done to make use of higher air velocities, closer distances from the nozzles to the goods and air application to both sides of the paper. Several successful applications of this type of equipment are today in the field, processing papers which have been impregnated or sized and normally are of the type that are subject to damage by touching a solid surface during the drying process.

Of course, one of the considerable savings that is achieved with this type of drier, is the elimination of the mechanical carrying equipment. In many of the treating operations, the cost of the mechanical equipment and its maintenance represents a very substantial portion of the total initial and operating cost of the drier. Also, in many instances, the highest possible mechanical speed of the drier is limited by the conveyor design. With the new high velocity air floater, this limitation is removed from the picture.

Another advantage of the floater is the fact that the air is supplied to both sides of the goods. This means that the drying capacity is double per square foot of drying space available. Also, uniform drying can be achieved since the moisture is being removed evenly from both sides of the goods.

The possibilities of this type of drier have just begun to be explored and more and more applications of this type will be forthcoming in the very near future.

DRYING ON THE PAPER MACHINE

Two new developments have taken place in the drying of paper by air within the paper machine.

The Dryjector

The Dryjector unit was developed for those machines which have very wide pockets between the driers. It has been the practice to inject hot dry air between the pockets of the machine to clean them of moisture concentration. Because the Grewin unit becomes inefficient when the size of the pockets increase, it has been necessary to use other means to eject these moisture vapors from inside the pockets. The Dryjector unit is designed to do this. Its basic idea is to supply the air to the center of the pocket. By applying the air at a certain velocity inside the pocket, the moist vapors are pushed or ejected to the outside of the pocket and into the main air system of the paper machine. Sometimes, special nozzles are used to bring the hot air to the center of the pocket and other times the support of the doctor blade is used as the duct to bring this hot dry air to the center of the pocket (see Fig. 2). The fact that the moist vapors are removed from the pockets improves the moisture distribution at the reel.

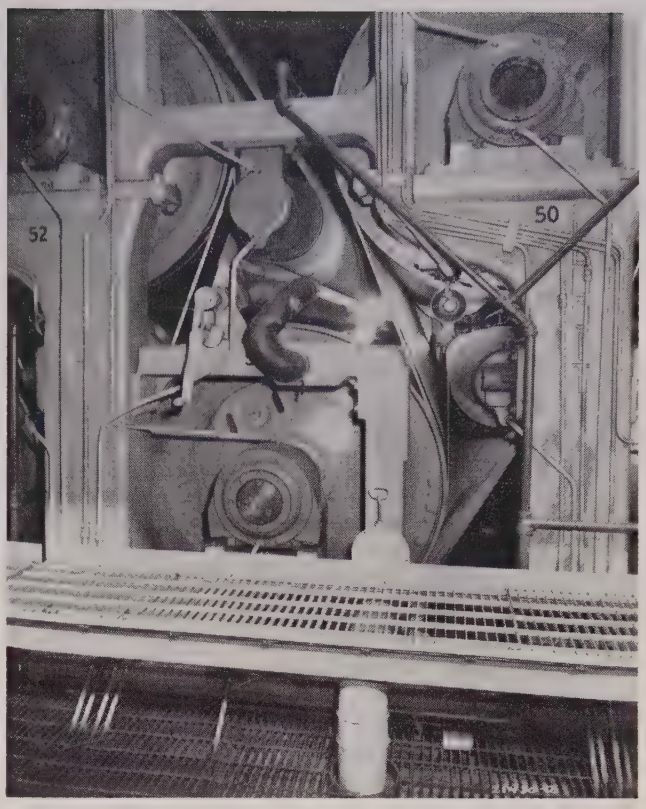

Fig. 2

This unit, however, does not bring about a fine control of the moisture profile. If exact moisture control of the web is necessary, other systems have to be added to the machine air system. As mentioned before, the high velocity drier with sectionalized control, will give the final moisture correction.

The Moist-Selector

The Moist-Selector is the latest development in the paper machine line which combines the features of the high velocity drier and the normal air system supply to the paper machine hood. From previous discussion, a machine really needs two units to effect a complete moisture correction: (1) a complete paper machine air ventilation system which will make a rough moisture correction, (2) a high velocity drier with a sectionalized control to complete the moisture correction within a small variation.

In some types of paper machines, where nozzle pipes are tolerated within the pockets, the Moist-Selector unit will combine the effects of two units. Because the air is applied to all the pockets, a rough moisture correction is achieved. Secondly, because the air is applied at high velocities, directly to the paper, additional drying is obtained from this application. Thirdly, since the air is applied evenly along the machine, this would be a major air makeup unit for the paper machine. Finally, by the design of special nozzles, the air discharging from these nozzles can be controlled across the trim of the machine in the same manner in which the air discharging from the high velocity dryer is controlled. This sectional control is normally made so that the operator can shut off any particular section within the paper machine to effect the correction. For all practical purposes, the Moist-Selector will operate as a high velocity unit. However, it is thought that the Moist-Selector will perform a greater correction for horsepower input, and create less detrimental effect to the goods in those papers where the moisture correction has to be done at a relatively low rate.

Presented at the meeting of the Berkshire District of the New England Section, held in Pittsfield, Mass., March 6, 1961.

A New Approach to the Measurement of Roughness and Porosity of Paper

A. J. W. SWEERMAN

Because the mathematical treatment of the nipspreading of a liquid drop over a paper is very difficult, another apparatus has been designed to bring liquid onto the paper. From the results obtained with this new method two quantities can be calculated, which correspond to the roughness and porosity of the paper.

In this paper a method is described for the simultaneous determination of the roughness and porosity of a paper.

The direct motive for this investigation was the described nipspreading tests in the literature (*1, 2, 3*). With these tests it is reasonable to expect that the roughness and porosity of the paper will affect the length of the spots in a different way if different liquids are used. It would seem desirable to calculate separately roughness and porosity from the nipspreading tests. However, it appears very difficult if not impossible to give an acceptable mathematical treatment of the manner in which a drop is spreading in the nip. For that reason the author looked for a method with a more easily understandable interpretation.

METHOD

The paper is drawn passed a rectangular slit filled with liquid with a uniform velocity (Figs. 1 and 2). During this movement the liquid fills in the valleys of the paper surface and at the same time penetrates into the paper.

The liquid quantity, R, that remains in the valleys of the paper surface is independent of the kind of liquid and of the speed of the slit with respect to the paper. The liquid quantity that penetrates is equal to:

$$K\sqrt{\gamma t \cos\theta/\eta},$$

in which:

- γ = the surface tension of the liquid, which varies in the experiments from 25 to 30 dyne per cm.
- η = the viscosity of the liquid, which varies from 0.015 to 0.60 poise.
- t = the penetration time, which is the time necessary for a displacement over one slit width. In our apparatus the slit width was 0.2 mm. and the speed 0.5 to 10 cm. per sec. This results in a penetration time from 0.04 to 0.002 a sec.
- θ = the contact angle of the liquid on paper. For the paraffin-oils used the wetting was certainly complete so that $\cos\theta = 1$ (4).
- K = a measure for the porosity.

Hence the formula that expresses the total liquid quantity transferred to paper per square centimeter is equal to $Y = R + K\sqrt{\gamma t/\eta}$.

APPARATUS

Figure 3 shows the slit with dimensions 0.2 by 15 mm. The slit can revolve around an axis that is parallel to the direction of movement of the paper, so that the longer side of the slit can follow the paper surface. As any slight variation in temperature results in a comparatively large viscosity variation, the metal block with the slit is provided with a thermometer.

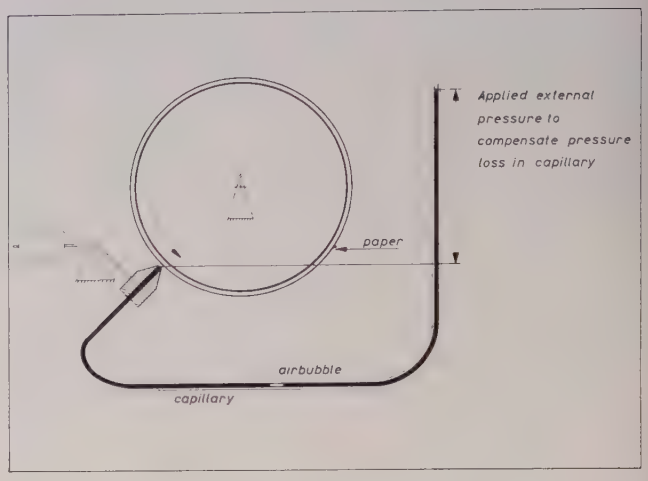

Fig. 1

The angle between the slit and the paper surface appears very critical and was so adjusted that the liquid quantity transferred to paper per square centimeter was minimal. The pressure exerted on paper by the edges of the slit was about 15 kg. sq. cm. But since the contact area between the slit edges and paper surface was not known exactly, this value is only an estimation. The paper was fixed directly on a steel cylinder, or on a cylinder with an offset rubber packing (Fig. 4), which was driven at constant speed.

The slit is connected with a capillary. From the rate of flow of an air bubble in this capillary Y can be calculated. The flow of the liquid through the capillary involves a pressure drop and this was compensated by an externally applied pressure. The external pressure was so adjusted that the speed of the air bubble, without the slit being in contact with the paper, was equal to that during the measurement. In this way one can assume the penetration from the liquid into

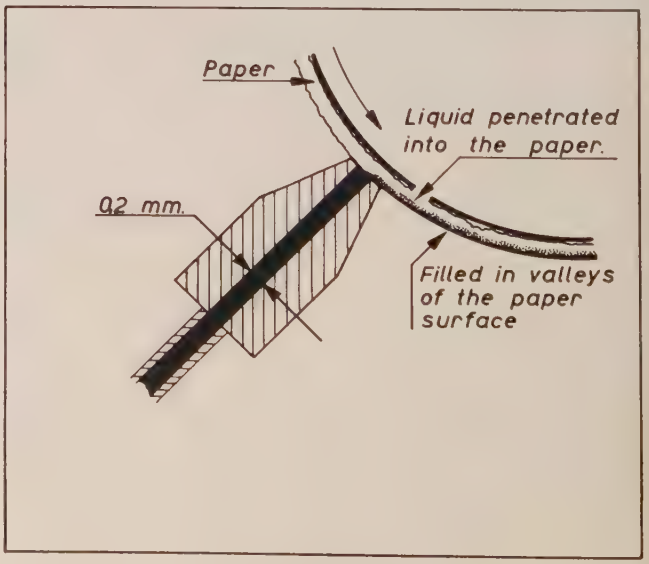

Fig. 2

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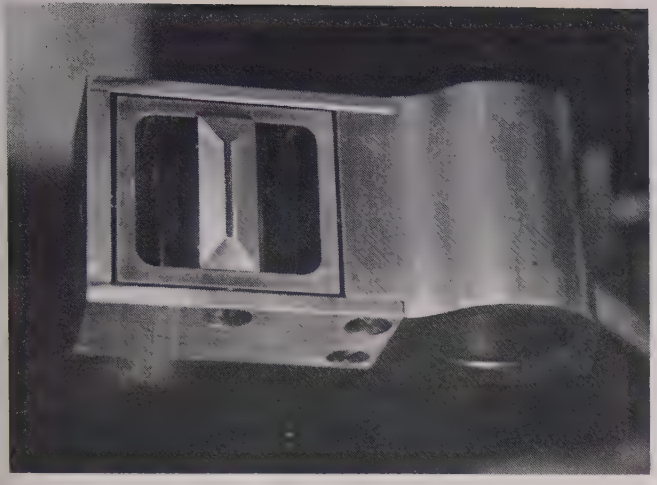

Fig. 3. Visible is the revolving cylinder with a paper sample. The slit is constructed with the open side upwards so that no air bubbles out of the paper can enter the silt

the paper is only due to the capillary pressure of the paper pores.

For every combination of paper, liquid, and speed of the paper movement the external pressure must be found by trial and error. The measurement, therefore, takes a long time.

RESULTS

As expected, a linear relationship was found between the factors Y and $\sqrt{\gamma\, t/\eta}$, as shown in the Figs. 5 and 6. Each plotted value is a mean of five to ten measurements.

For a number of papers the roughness R and the porosity K were calculated, and the latter was compared with the porosity V, calculated from the penetration volumeter curve (*5*). This instrument measures the volume of liquid that penetrates perpendicularly to the paper surface as a function of time.

	R	K	V
Wood-free offsetpaper	0.68	0.39	0.20–0.36
Wood-free writing paper	0.31	0.16	0.13
Wood-free m.c. paper	0.20	0.11	....
Machine coated paper, casein	0.16	0.08	0.13
Machine coated paper, starch	0.15	0.09	0.14
Art paper	0.00–0.03	0.14	0.14–0.18
Gravure paper 1	0.36	0.25	0.21
2	0.35	0.25	0.25
3	0.28	0.21	0.20
4	0.16	0.14	0.13
5	0.16	0.15	0.12

For this purpose, the quantity of air which has been displaced from the pores by the liquid is measured in a cali-

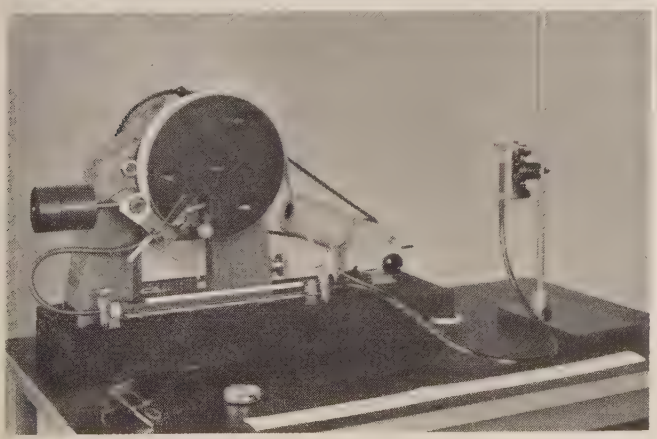

Fig. 4

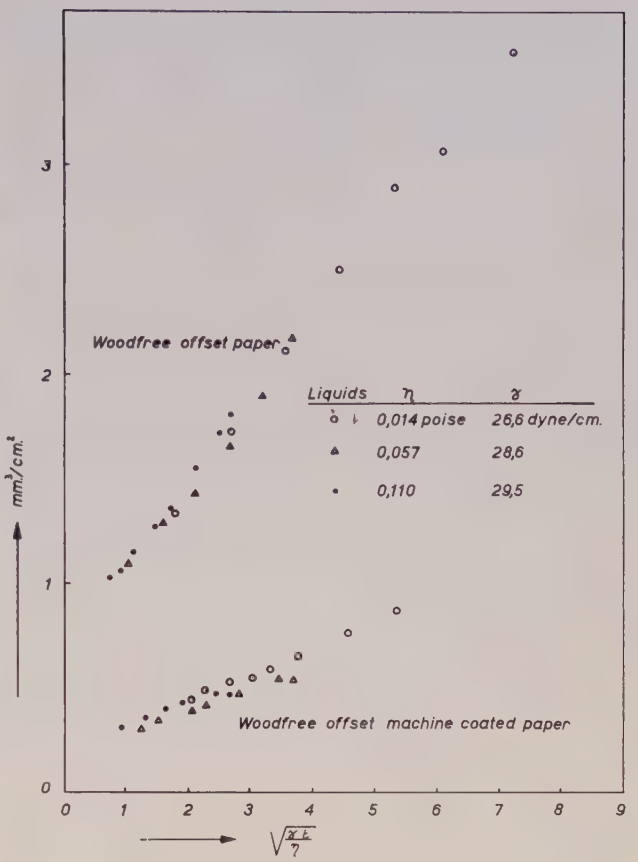

Fig. 5

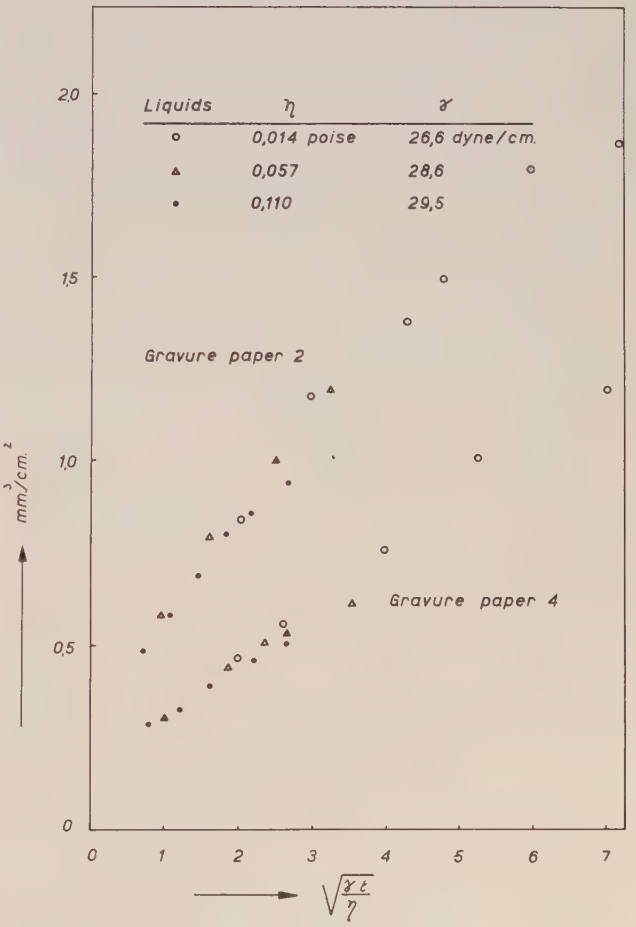

Fig. 6

brated capillary tube. From the speed of a liquid drop in the calibrated capillary tube the volume of penetrated liquid as a function of time can be calculated. Because the moment at

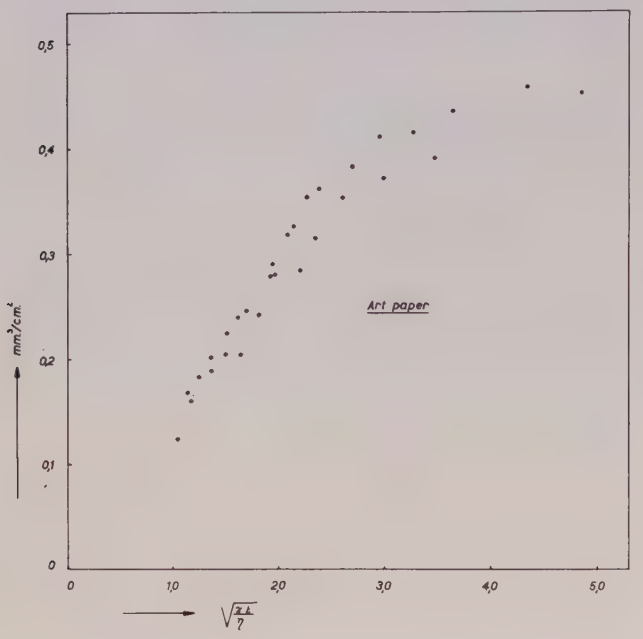

Fig. 7

which the penetration has started is difficult to determine, the curves mostly are somewhat displaced in reference to zero time.

All the reported results were measured with an offset rubber packing. The roughness R is expressed in cubic millimeter liquid per square centimeter paper. The porosity K and V are both expressed in cu. mm. sq. cm./$\sqrt{\text{dyne sec./cm. poise}} = 10^{-3} \cdot \text{cm}^{1/2}$.

Figure 7 is a plot of the results of an art paper. The bend in the curve is due to the entering of the liquid into the base paper. At that moment 0.4 to 0.5 cu. mm. per sq. cm. has

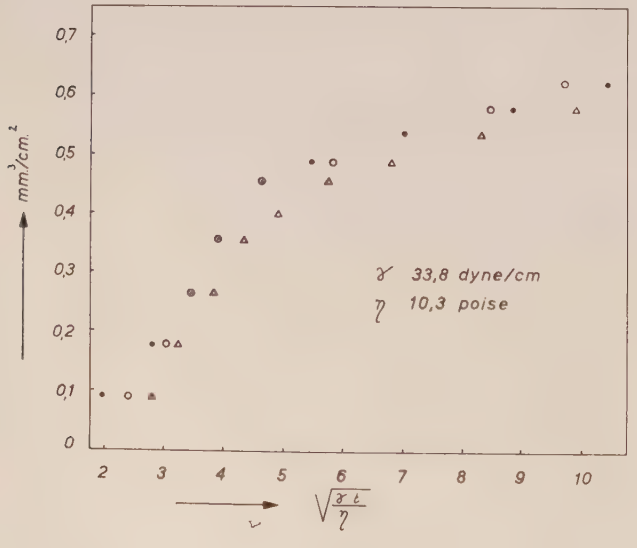

Fig. 8

penetrated, which is equivalent to a liquid layer of about 4 to 5 mu thickness. A similar bend is found in the penetration volumeter curve of this art paper (Fig. 8).

DISCUSSION

There is no sharp distinction between the valleys in the paper surface and the paper pores, but only a gradual transition and indeed this method measures roughness and porosity in an equivalent manner. Probably the porosity of the upper surface layer can be found more reliably by means of this method than by the penetration volumeter, and this is specially important for coated papers. A disadvantage of this method is the long time and the great experience that is needed to get reliable results.

LITERATURE CITED

1. Wink, W. A. and Van den Akker, J. A., *Tappi* 40: 528 (1957).
2. van Gastel, L. A., *IGT-Nieuws* 11: 176 (1958).
3. Proc. Patra Letterpress Methods Conference 1955 p. 12 (D).
4. Tollenaar, D. and Ernst, P. A. H., Taga Proceedings of the eighth annual technical meeting, 1956, part A, p. 37–41.
5. Tollenaar, D., *International Bulletin for Printing and Allied Trades* 73: 76 (1956).

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Factors Influencing the Testing of Gummed Paper Tape

E. E. WERLE

This paper discusses the factors involved in the testing of rewettable gummed paper tape. Since precise methods are not available for the determination of the important property of tape in regard to how well it performs, consideration is given to such artful factors as are involved in performing the tests and interpreting the results.

Two papers containing information pertinent to this subject have already been published (*1*, *2*). One article, "Simple Methods Measure Gummed Tape Effectiveness" (*1*) in which A. P. Schulz of Spiegel, Inc. collaborated, describes methods by which a consumer can evaluate a tape for performance in his specific applications. In the other article "Research Reveals Key Factors Affecting Animal Glue Sealing Tapes" (*2*) a relatively comprehensive discussion of testing of tape is included. These articles disclose many of the factors that sholud be considered in the evaluation of sealing tapes, some of which will be discussed here.

In short, gummed tape should stick immediately upon application and produce a firm permanent bond. It should also retain these properties upon proper storage. As an example of the importance of storage quality I have had, among others, the following experience. One day I was in a delicatessen store purchasing some cold cuts and noticed that the counterman wrapped some in paper and applied a short piece of tape to seal it. This tape had poor sealing quality, as evidenced by its slipping and not bonding immediately, necessitating the man to hold it in place for a short while. I asked him if the tape always acted that way, and he explained that this was because it was old. Thereupon I told him that if he would place the roll of tape on a hot radiator for a couple of hours, it would stick much better. He said he would try it. After a couple of weeks when I returned to the store, I noticed that when he applied the tape it stuck immediately. Upon questioning, he told me that the heat treatment made the difference. This is merely an illustration of what can happen in the field. In this case, the tape was probably satisfactory when he first received it, but lost its tack on storage. The important point is that this consumer thought that a tape losing its tack quality is a normal occur-

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rence, when, in fact, it is not the case with good tape stored properly.

When we come right down to it, the matter of evaluating a roll of tape for its on the spot performance quality, could be very simple. Subjectively, if a packager makes a seal in the customary manner and the package remains sealed, the tape is judged to be satisfactory, and that's it. However, such a result is only good for that tape at the time it is tested. A later test could show different results for many reasons, among which could be dispensing different amounts of water on the tape, change in open time or possible deterioration of the quality of the tape on aging.

In "Simple Methods Measure Gummed Tape Effectiveness" (*1*), it is illustrated that one can judge the quality of gummed paper tape by making a few simple tests. With these tests, a conscientious investigator can establish the performance quality of a tape for a specific use. However, though such tests do help in judging a tape, they are not primarily suitable for research or control purposes. In "Research Reveals Key Factors Affecting Animal Glue Sealing Tapes" (*2*), it is illustrated that moisture is an important factor in manufacturing, testing, and performance of tape.

REASONS FOR INSTABILITY OF SOME TAPES

I believe, if we digress a moment, we will be able to clarify the role of moisture in tape to the extent that it will eliminate some of the discrepancies in qualities of tapes that vary as a result of testing at different times.

Through a long-testing program, in which the effect of of aging of 60-lb. sealing tapes was studied, we arrived at the general conclusion that those coated with animal-glue based formulations are generally stable on aging when they contain optimum moisture contents, around 4% whereas those containing 7% or more are generally unstable, and those containing between 4 and 7% are unpredictable: some lose tack and some do not. Since most tapes are produced with moisture contents in the latter range, it becomes apparent that much confusion can result in the industry. With the added factor, that tapes lose their desirable properties more rapidly in cold atmospheres than in warm atmospheres, the weather is brought into account and still more confusion can prevail. Therefore, if tapes were produced with optimum low-level moisture contents and stored properly, at least, the variation of quality due to aging could be practically eliminated.

Without having performed the required physical tests on the actual coatings, there is indication that the aging quality of animal-glue based coatings correlates with that which would be obtained if crystallization occurred. For example, the coating of a freshly made tape, having been hot-dried, is considered to be amorphous and exhibits satisfactory performance qualities. In contrast, the same tape after having been subjected to a cold humid atmosphere, overnight develops poor qualities in that it wets poorly and exhibits much poorer tack. And further, heating this tape usually restores its wetting and tack qualities to about the level of the original. This behavior of tape coatings correlates with published data (*3*) in which x-ray diffraction studies reveal that hot-dried gelatin films are amorphous whereas cold-dried films are crystalline. These phases are reversible: amorphous films become crystalline when they are subjected to cool, moist atmospheres, and crystalline films heated to about 140°F. or over become amorphous.

Now then, if this matter of crystallinity of gelatin were the only factor to be considered, it would be possible to lay down specifications to produce tapes from a specific coating formulation at different times to have a specific level of tack. However, this cannot always be done for reason that there is at least one other factor to consider. We think that orientation occurs in the direction that more or less hydrophylic groups of the glue molecules exist on the surface of the coating. The degree and direction of such orientation could be the result of electrostatic conditions prevailing while the tape is being dried. This hypothesis, then, might be tentatively accepted as a possible explanation as to why the same coating formulation does not always produce the same quality tape on different days.

So far, this whole business looks quite complicated and, in fact, it is. The reasons are that neither a standard tape for control is avaiable, nor is there an exact means for determining its adhesive qualities. In order for you to appreciate this, I would like to relate some of our experiences with brush-type dispensers.

BRUSH DISPENSER CHARACTERISTICS

With the Counterboy A dispenser, used in the determination of the McLaurin tack and open time qualities, we run into difficulties in applying constant quantities of water, even though our machine is equipped with a mechanical device to dispense tape at the rate of 10 in. per second.

First of all, a freshly cleaned brush supplies less water to a tape, as low as 6 lb. per ream, than a brush in constant use, 10 lb. or more at times. Also, the brush in constant use does not consistently apply the same quantity of water indefinitely. In fact, one cannot depend on the results of unknown tapes when more than four are tested without checking a reference tape. Sometimes the McLaurin tests go up for the reference tape and sometimes they go down, without apparent reason. Such variations can occur more frequently with one technician than with another. Possibilities are that, one operator will run the tests at a slower rate, or might pull a tape out quicker than another, or might leave measurable time elapse between testing the different specimens. Here is an illustration of another inconsistency in testing. We have a reference tape that tests around 35 McLaurin in a 2.5-sec. cycle. In preparing for a series of tests, it was established that the normal 10 lb. of water per ream was being applied, but it tested over 50 instead of its normal 35. Inspection of the wetted surface revealed a thin ribbing of the applied water rather than a relatively uniform layer as normally obtained. Upon squeezing down on the brush cover plate and dispensing a number of pieces of tape, more uniform wetting ensued and the tack of the reference tape leveled to around the 35 previously established. Possibly this might not have happened had the brush been in use for a long time. Nevertheless, it is a situation that can occur and illustrates that both the amount of water dispensed and the uniformity of wetting must be controlled.

Another experience with a tape coated with a special formulation was that after 10 McLaurin tests showed 5-sec. tacks at the level of 72, the next 14 tests averaged to a level of 57. Following this, an animal-glue based tape averaged a normal 83 for the first 10 tests and 82 for the second 14 tests. No change in the brush had been made. A possible explanation is that the special tape transferred some of its coating to the brush which altered the character of the moistening medium.

This, then, brings up the problem of interpreting McLaurin tacks and other tests involving the bonding qualities of tapes. If we carry out a test with a relatively clean brush and get certain results, there is no assurance that such results will be obtained when the brush is used for the tape in question for extended periods of time. In commercial packaging, a brush is used continually, and the characteristics of the tape under such circumstances would be of more value than those determined according to the TAPPI method for McLaurin tack, which specifies a practically clean brush.

Another characteristic of brush dispensers is that they apply more water to heavy caliper tapes than to lighter ones. A recent test with a Counterboy Model 500 double-brush dispenser showed 22 lb. per ream to have been applied on a 150-lb. laminated tape as against 13.7 lb. on a 60-lb. tape. These amounts were applied to specimens being tested for McLaurin tack.

Other brush characteristics are revealed with high-speed electric dispensers. For example, when using a Clip-A-Tape dispenser (54 in. per sec.) for determining the wetting quality of tape by noting the length of tape that can be dispensed before apparently unwetted spots appear, it was noticed that the rate at which the operator removed a dispensed piece affects the uniformity of wetting of the following piece. More uniform wetting is obtained on specimens following one that had been removed slowly than one removed rapidly, and vice versa. This can be repeated indefinitely.

The explanation could be that when slow removal is involved the coating of the tape is to some degree transferred to the brush, whereas with rapid removal, water is merely applied to the tape, and its flow through the tip of the brush actually cleanses it. This correlates with the phenomenon that a brush can be made to wet a glue tape uniformly at high speed by rubbing some of the tape's coating on it. And, further continued dispensing of the same tape over the same brush causes a reversion to the normal spotty wetting after a number of strips have been dispensed.

CHARACTERISTICS OF SPOTTY WETTING

At this point there are probably some of you in the audience who are visualizing undesirable sealing characteristics of spottily wetted tapes. Let me assure you that, though poor sealing qualities and spotty wetting can go hand-in-hand, normal good quality tapes can show spotty wetting and still produce good seals. Actually, such spotty wetting, as obtained in high speed dispensing, has been indicated by tests to be beneficial instead of detrimental to the tape's performance, both from the standpoint of immediate grab quality and open time quality. This can be readily appreciated by considering the comparison of the performance qualities of the same tape, spottily wetted and completely wetted.

Upon probing the apparently unwetted spots with a sharp instrument immediately after dispensing, they are revealed to be wet. Apparently, whatever moisture was applied was absorbed and left a tacky area.

The ridges of moisture surrounding these areas have some visual thickness even after the lapse of open time. Hence, they provide residual water which is available for completing the seal.

The more rapid bonding quality of the apparently unwetted spots is made evident in the test used for determining time for fiber tear. Fiber is first torn at such areas that appear to be unwetted in a second or two, whereas, it requires some 18 sec. for the entire tape to adhere.

As to the completeness of final seals, the results of this test were that both the spottily wetted tape and the completely wetted tape gave 100% permanent adherence when they were applied immediately to 90-lb. kraft. Upon application of the tapes after 30 sec. open time, the spottily wetted tape showed 80% permanent adherence as against the completely wetted tape, only 40%.

The amount of water dispensed on the tape that was spottily wetted, was determined to be 12 lb. per ream. In comparison, the same tape completely wetted, acquired 10.8 lb. per ream. Complete wetting was accomplished by causing the tape to contact the trailing edge of the brush by the use of a curved plate attached to the brush cover.

One could claim that the difference in percentage adhered was the result of the difference in the amount of water applied. This could be so. However, the point is that the spottily wetted tape gave a better permanent seal after 30 sec. open time.

To repeat, this does not mean that tapes that are actually poor in quality and show very spotty wetting will possess desirable sealing qualities. It refers only to normal good quality sealing tapes dispensed rapidly.

All of these characteristics of brush dispensers have been brought to your attention to establish a foundation for discussing the factors to consider in the evaluation of tapes. By now, you must realize that the method of moistening a tape is a very important factor, which even with electric dispensers, still involves the human element. Therefore, any of the current test methods for establishing a tape's adhesive qualities must of necessity include a reference tape tested at the same time.

REFERENCE TAPE

A reference tape could be a roll of good quality commercial 60-lb. sealing tape, coated with an animal-glue based formulation and containing around 4% of moisture. Storage of such a roll or rolls in a sealed package on the high shelves of a room (warm atmosphere) would ensure their uniformity over long periods of time. The average of replicate tests could then be established as a standard for control purposes. Perhaps if the effort were put forth, a gummer could produce tape repeatedly from a standard formulation, under carefully controlled conditions, which would be suitable as a universal standard. However, at the moment, this appears to be difficult for the reason that orientation of the molecules on the surface of the tape's coating might not be controllable.

SPRAY WETTING

It is believed that all investigators recognize that a brush dispenser is not entirely reliable for applying the uniform layers of exact quantities of water on tape surfaces, necessary for testing purposes. Yet, since most commercial dispensers utilize brushes, this means of wetting tape must be given serious consideration in testing.

Roberson and Roberson (4) recognized the difficulties involved with brush moisteners and devised a spraying device which apparently is satisfactory. They were able to get much more uniform McLaurin tack tests. This, therefore, sheds a ray of hope toward answering the problem of applying a definite amount of water to tape. Incidentally, our tests showed that a difference of 1 lb. of water per ream of tape affects the tack to the extent of about 18%. When you consider that in the McLaurin test the 1 lb. of water weighs 17 mg. and has a thickness of only about 5×10^{-5} in., you can appreciate the difficulty in controlling it.

In the event that the Roberson's (4) spray moistening system proves acceptable and it is made available to the industry, a uniform quantity of water could be applied to any weight tape, and the necessity for a reference tape would be eliminated. On the other hand, such tests would have to be augmented with an extended series of tests with a brush dispenser to determine if continuous commercial dispensing of a tape would alter its tack. This could happen if excessive amounts of a tape's coating deposited on the brush.

SOME OTHER FACTORS

Now let us discuss some of the other factors to be considered in line with evaluating gummed paper tape by existing methods.

Age of Tape When Tested

First of all, our tests indicate that the results of testing rolls of tape immediately after producing them are not always the same as when they are tested after aging in the package for a week or two. This was made evident by actual tests and reports from producers who claimed that their fresh products performed satisfactorily, but after a week or two, did not. Most of these occurrences have been associated with those tapes containing too high moisture contents. However, in a recent series of tests with normal moisture-content tapes, we noticed a distinct difference in the dry curl qualities of some of the rolls when tested immediately after producing and again two weeks later. These fresh specimens, upon being placed in a drying oven, acquired reverse curls (glue on the outside), but after two weeks in the bundle, they showed normal curls (glue on the inside). From this,

it becomes apparent that rolls of tape should be aged in the carton for some time before the final evaluation tests are made. Just how long, is still something to determine.

Need of Replicate Determinations

A further consideration in the testing of tape is that one test is not representative. This is so because there is a lack of uniformity between different rolls of tape from the same slitting and between different areas of the tape on the same roll. We find that the average of at least four determinations usually gives a reliable result.

Uniform Moistening

In the performance of any test that involves the moistening of tape, water must be applied, not only in a constant amount, but also in a uniform manner.

PUBLISHED TESTS PROCEDURES

In the "Key Factors" and "Simple Methods" articles, all of the following determinations are discussed: moisture, ream weights, wetting quality, blocking quality, McLaurin tack, immediate grab, open time, and time for fiber rupture. The characteristics not covered are dry curl and wet curl qualities of tapes.

CURL OF TAPES

It is obvious that if a tape develops excessive curl in the dry form, or after moistening, it would be troublesome to a packager. Therefore, determinations of these properties are desirable.

A method for the determination of the degree of curl of gummed paper with changes in relative humidity is under consideration by the Gummed Industries Association. Though this method calls for 4-in. square specimens, it could be modified to utilize convenient lengths of gummed tape of any width.

Briefly the method consists of placing specimens in conditioned cabinets or rooms held at respectively 20, 40, and 60% R.H. Note is made of the degree of curl after 15 min. exposure, then again after 15 hr.

No standard method exists for evaluating the curl developed in tape after it is moistened. We use a method which consists of dispensing a 30-in. strip, attaching one edge to a shelf and allowing the free length to hang in the air. Curl develops in the direction of the glue on the outside. The time required for the free end of the tape to acquire $^1/_2$ a turn is noted, and the degree of curl after 30 sec. is noted. The timing begins when the specimen is cut on the dispenser.

Normal sealing tapes require about 30 sec. to reach $^1/_2$ turn, while others do so in as little as 10 sec. After 30 sec. some tapes reach the shape of a closed tube.

ESTIMATING SHELF LIFE OF TAPES

As to the possibilities of determining shelf life, there is no substitute for allowing cartons of rolls to age for months or years and rechecking their qualities. However, since we found that tapes lose their good qualities more rapidly in the cold than in normal or warm temperatures, some idea of shelf life could be obtained by placing rolls of tape in individual, sealed containers and storing them in a refrigerator. If after one month, for instance, such rolls would test the same as similar ones stored in the room, it could indicate that the tape would have a good shelf life.

GUMMED INDUSTRIES ASSOCIATION PROGRAM

Members of the Gummed Industries Association are aware of the need for specific test methods to establish the performance qualities of gummed tape, and are doing what they can to make the existing ones universally applicable.

At the present time, they are attempting to standardize the McLaurin test so that different laboratories can check each other. A round robin testing program last year in which five collaborators participated, revealed rather poor agreement.

For the present, the McLaurin tester is used more universally than any other type. And, until a better and completely mechanized tester is invented, any effort to improve the results obtainable will be justified.

NEW TESTER

What we really need is a tester that is completely automatic to eliminate the human factor. It would be highly desirable to have a machine that would establish the force required to separate a bond through lateral shear. If the machine could operate on controlled but variable open times and closed times, much could be learned in the way of establishing the bonding characteristics of a coating. If, in addition, the amount of water applied could be varied at will, an idea of how this affects the tack could be established.

There is a prototype of such a machine (The Wetzel tester) being developed at The Mid States Gummed Paper Division of Minnesota Mining and Manufacturing Co. Outside of the problem of applying the water to the tape in a completely satisfactory manner, this tester appears to have the necessary design characteristics to be highly acceptable.

DESIRABLE PROPERTIES OF SEALING TAPES

Sealing tapes are most satisfactory if they possess the following properties in practical application:

They should be firm enough to dispense readily and apply with ease;

They should be free of excessive dry curl qualities that would interfere with dispensing or applying the tape;

They should not curl excessively after moistening, or enough so as to become troublesome in applying, especially when extended open time is necessary in the application;

They should not be overly sensitive to the amount of water applied in practice. Equally good results should be obtainable with single brush or double brush dispensers;

Their coatings should not transfer to the brush to such a degree that frequent cleaning is necessary for satisfactory operation;

They should stick to the surfaces immediately upon application, as any initial slippage not only wastes time but causes unsightly packages;

Above all, they must produce seals that do not pop off upon drying.

All of these properties should be manifested in December as well as in May.

Adequate methods for determining these qualities must be devised.

CONCLUSION

Though this talk revealed some factors that should be considered to get more reliable results with the existing test methods, they are not the answer to precise evaluation of tapes. Much work remains to be done in the way of developing better methods, and necessary equipment to ensure universally reproducible results.

LITERATURE CITED

1. Schulz, A. P. and Werle, E. E., *Package Engineering* 5, No. 2: 60–67 (1960).
2. Werle, E. E., *Paper Film and Foil Converter* 34, No. 2: 23–29, 91–92; No. 3: 42–46; No. 4: 54–59 (1960).
3. Literature Review—"The Properties of Gelatin Films," *British Gelatins and Glue Research Association Abstracts* 8, No. 1, 1–8 (1957).
4. Roberson, C. E. and Roberson, W. B., *Tappi* 42, No. 11: 895–903 (1959).

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Evaluation of Currugating Medium and Factors Affecting the Ring Crush Test Results

OTOMAR ŠEDIVÝ and JAN KUBÁT

The authors studied the statistical correlation between the ring crush resistance of corrugating medium and the flat crush test, breaking strength, bursting and tearing strength, density (bulk) of paper and the basis weight. They found a practically important correlation between the ring crush and flat crush values. On the other hand, the correlation of ring crush and breaking strength, burst factor and tearing strength of paper is very limited. The ring crush resistance depends on the density of paper with maximum at 0,55 g per cc. Maximal ring crush results was obtained with 500 ml. C.S.f.

Unusual attention has been paid during the last 10 years to the development of the corrugated board industry throughout the world. New fibers with special properties, such as semichemical pulps, have been developed and systematical studies opened a new sceintific approach to the problems of corrugated board.

Several new testing methods, imitating strains and stresses to which the corrugated board and its components are subject under practical utilization, have been developed. These new testing methods, generally known for 6 to 10 years, are in broad use but, in spite of that, the older classic paper and board testing methods are frequently used for the same purpose. Because different results are usually obtained with different methods, there exists a certain danger that several corrugated boards or corrugating materials could be differently evaluated if a reasonable correlation does not exist between the methods used. We thought therefore that it would be desirable to investigate some fundamental physical relations between some new and old testing methods for corrugating materials.

We performed a series of tests with different raw materials, including wastepaper; chemical, high-yield, and semichemical pulps; groundwood, etc. Using statistical methods, we found the correlation coefficients for the most important tests. We deal in the paper with our partial results concerning mechanical and other physical properties of corrugating medium.

The flat crush test is one of the most important methods for evaluation of the corrugated board's quality. The resistance to the flat crushing action depends largely on the choice of material for the corrugated layer. Special attention should therefore be paid to the evaluation of the corrugating medium. The Concora medium test seems to be one of the modern and most reproducible methods for testing this board's quality. The practical utilization of the Concora medium test is, however, limited to the American continent, whereas in Europe, other methods, such as the ring crush test and other tests normally used for paper testing are preferred until now. We would like to prove that many of these testing methods, such as the bursting and tearing strength, have only a very limited correlation with the flat crush test, whereas the breaking length and the folding endurance of paper are practically in no direct relation with the quality of corrugated board. On the other hand, we found the existence of a very close corrleation between the flat and ring crush resistance.

The ring crush test was chosen as the most suitable criterion for the evaluation of corrugating medium. All other tests were compared and corrleated with this basic method.

Otomar Šedivý and Jan Kubát, Pulp and Paper Research Institute, Prague, Czechoslovakia.

Table I

Ring crush resistance, lb./in.	*Flat crush, lb./sq. in.*
4.32	11.9
3.81	11.9
8.40	22.9
4.15	11.8
6.15	17.5
4.98	14.9
5.55	12.1
4.48	12.8
3.47	8.7
3.19	8.8
5.94	15.6
5.88	15.6
4.26	11.7
5.77	17.2
3.47	9.2
5.05	14.1
5.50	15.5
6.27	14.9
4.87	13.2
5.32	15.6
5.77	17.5

TESTING CONDITIONS

Ring crush test: paper strips of $6^1/_2$ in., standard crushing press.

Flat crush test: standard crushing press. Test specimens with area of 50 sq. cm. (7751 sq. in.). Specimens were cut by means of a cutting device of original design, preventing the damage of edges.

All test specimens were subject to conditioning for 24 hr. at 65% R.H. and at a temperature of 20°C. (68°F.).

Each test figure in the graphs published is a mean of 10 individual tests.

RELATION BETWEEN THE RING CRUSH AND FLAT CRUSH RESISTANCES

We investigated the relationship between the ring crush resistance and the flat crush test results on the same sample of corrugating medium and corrugated board manufactured from this medium. A mixture of neutral sulfite semichemical pulp with wastepaper and a high-yield sulfite pulp as well as a pure wastepaper pulp were used as raw materials for corrugating medium. The corrugating machinery used was not of the up-to-date type. It is very probable that an improvement of the flat crush value could be obtained by using the modern corrugating machinery. We performed a series

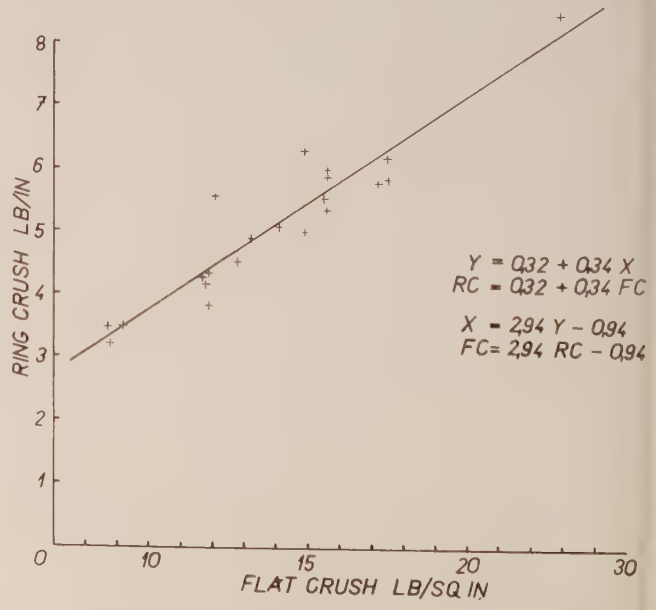

Fig. 1. Relationship between ring crush and flat crush resistance

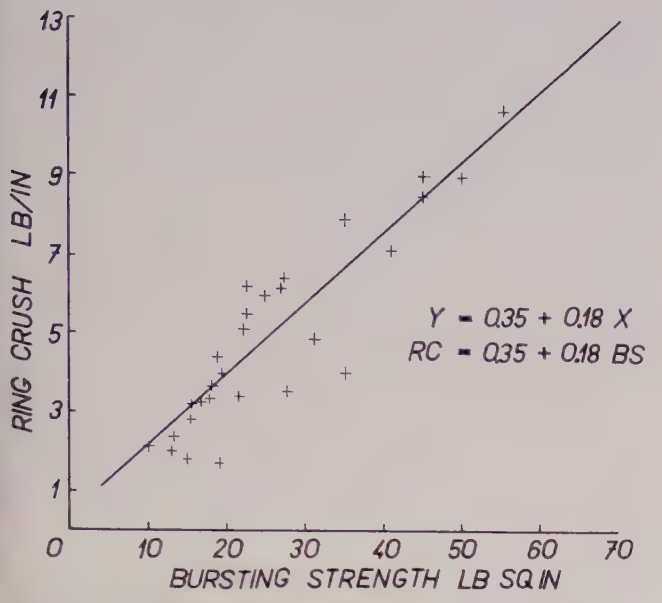

Fig. 2. Relationship between ring crush resistance and bursting strength

of tests, the results of which are summarized in the Table I. Basis weight of corrugating medium was maintained on identical level in all tests.

When analyzing our results, we obtained a surprisingly high correlation coefficient of 0.92. This high correlation indicates that the relationship is nearly linear. It is therefore quite possible and practical to foresee with fair reliability, the flat crush value from the ring crush test results. This correlation may be, of course, applied only to the same fiber furnish, basis weight, and corrugating machinery. This confirms the results found previously by other authors.

The general relationship may be expressed by means of a straight line of the following equation:

$$y = 0.34x + 0.32 \quad \text{(see Fig. 1)}$$
$$RC = 0.34FC + 0.32$$
$$FC = 2.94RC + 0.94$$

where RC is the ring crush and FC the flat crush resistance.

The high correlation coefficient proves that our choice of the ring crush resistance as fundamental criterion for the evaluation of corrugating medium was fairly justified. In this line, our results agree with those obtained by Smith.

RELATION BETWEEN THE RING CRUSH RESISTANCE AND THE BURSTING STRENGTH

The bursting strength of corrugating medium was measured on a Mullen tester. A similar test series as mentioned above was conducted and the results are given in Table II. We found a correlation coefficient of 0.83 which may be significant within certain limits. The quality of corrugating medium can therefore be evaluated by means of the bursting strength only to limited extent. The equation of the straight line illustrating this relationship (see Fig. 2) follows:

$$y = 0.35 + 0.18x$$
$$RC = 0.35 + 0.18BS$$

where RC is the ring crush resistance and BS the Mullen bursting strength.

RELATION BETWEEN RING CRUSH RESISTANCE AND THE TEARING STRENGTH (ELMENDORF)

We investigated, in the same manner, the relationship between the ring crush resistance and the tearing strength obtained on an Elmendorf tester. Results are shown in Table III. Our calculations resulted in a correlation coefficient of 0.74 which is too low for a dependable application of a relationship. The Elmendorf tearing test cannot therefore be used for evaluation of the quality of corrugating medium.

Table II

Pulp	*Freeness, C.S., ml.*	*Basis weight of paper lb./ 1000 sq. ft.*	*Ring crush resistance, lb./.in*	*Breaking length, m*	*Bursting strength Mullen, p.s.i.*
100% NSSC pulp (beech)	660	21.8	3.31	2776	17.6
	660	24.7	3.96	2584	19.3
	660	31.3	6.40	2840	26.7
	425	19.8	3.26	2680	16.7
	425	25.5	4.43	2226	18.7
	425	31.5	6.62	2059	22.4
80% NSSC pulp 20% Wastepaper stock	425	19.9	2.37	2506	13.6
	425	24.7	4.07	2621	....
	425	30.3	5.50	2622	22.4
	660	20.5	2.59	2425	....
	660	24.5	3.97	2450	....
	660	31.5	5.98	2819	24.4
60% NSSC pulp 40% Wastepaper stock	425	21.0	2.35	2222	....
	425	24.9	3.13	2227	....
	425	32.3	5.10	2145	22.2
	660	22.5	2.80	2155	15.3
	660	25.5	3.64	2244	17.9
	660	33.8	5.98	2506	....
40% NSSC pulp 60% Wastepaper stock	425	20.0	1.79	1971	10.5
	425	25.2	2.97	2050	....
	425	30.8	4.13	2244	....
	660	21.1	2.01	2047	13.0
	660	26.2	3.19	2085	15.6
	660	33.1	5.25	1976	....
100% Wastepaper stock	No beat	21.6	1.34	....	....
	No beat	31.4	3.41	....	....
	No beat	34.8	4.25	....	....
60% NSSC pulp 40% Wastepaper stock	425	21.0	3.41	3260	21.3
	425	25.5	6.15	3300	26.7
	425	31.5	7.90	3293	35.5
	425	21.9	4.82	5063	31.0
100% NSSC-pulp[a]	425	27.0	7.12	4515	40.9
	425	35.0	10.65	4267	55.2

[a] This Pulp was exceptionally well screened.

RELATION BETWEEN THE RING CRUSH RESISTANCE AND THE BREAKING LENGTH

Similar investigations of a relationship between the ring crush resistance and the breaking strength (in terms of breaking length) gave a correlation coefficient of 0.57. The interdependence of the two test values is therefore unsignificant (see Table III).

SOME EFFECTS OF THE STOCK PROPERTIES ON ON THE RING CRUSH RESISTANCE OF CORRUGATING MEDIUM

After the critical examination of different testing methods we investigated some factors, which, according to our opinion,

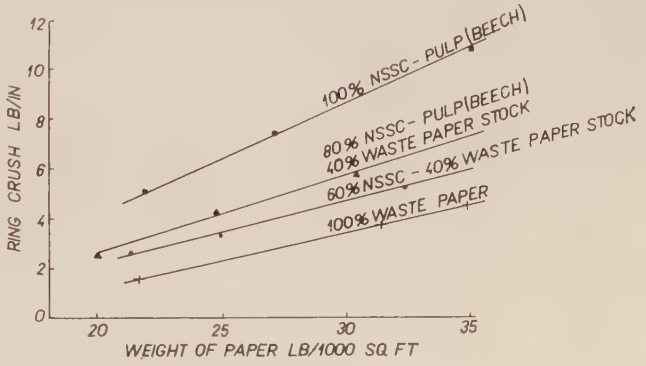
RING CRUSH LB/IN
WEIGHT OF PAPER LB/1000 SQ FT
100% NSSC - PULP (BEECH)
80% NSSC - PULP (BEECH)
40% WASTE PAPER STOCK
60% NSSC - 40% WASTE PAPER STOCK
100% WASTE PAPER

Fig. 3. Relationship between ring crush resistance and basis weight

Table III

Pulp	Freeness C.S., ml.	Basis weight of paper lb./1000 sq. ft.	Ring crush resistance, lb./in.	Tearing strength (Elmendorf), g.
Kraft pulp	735	16.6	1.9	147
	735	25.2	2.9	192
	735	31.1	3.7	264
	735	39.5	5.0	320
	735	48.2	5.9	448
	500	17.2	2.8	134
	500	26.3	5.3	224
	500	35.2	9.1	296
	500	44.0	10.9	488
	500	49.2	13.1	536
	362	16.5	2.6	106
	362	25.0	5.3	204
	362	36.0	9.1	320
	362	42.4	13.5	416
	362	42.7	13.0	424
	210	17.7	2.7	120
	210	25.8	5.3	184
	210	33.8	9.6	264
	210	41.8	11.8	356
	210	50.2	13.3	504
Wastepaper stock	270	25.6	2.8	72
	270	30.3	4.7	136
	270	32.7	5.0	130
	270	36.8	5.6	149
	270	38.9	4.4	117
NSSC pulp—beech	660	31.1	5.0	48
	660	32.1	5.9	60

should affect the ring crush resistance of corrugating medium. We paid special attention to the effects of pulp freeness, density (bulk), and basis weight of paper.

Effect of the Basis Weight of Paper

We have found that when the same raw materials (of the same freeness) are used as furnish, there will exist a linear relationship between the basis weight of paper and its ring crush resistance. This relationship is illustrated in Fig. 3 where different raw materials, such as semichemical pulp, mixed wastepaper stock, and mixtures of these two pulps are compared. We can see that an increasing basis weight of a semichemical sheet results in substantially greater relative increase of ring crush resistance than on a sheet made from 100% wastepaper stock.

In Fig. 4 we plotted the ring crush resistance of a kraft

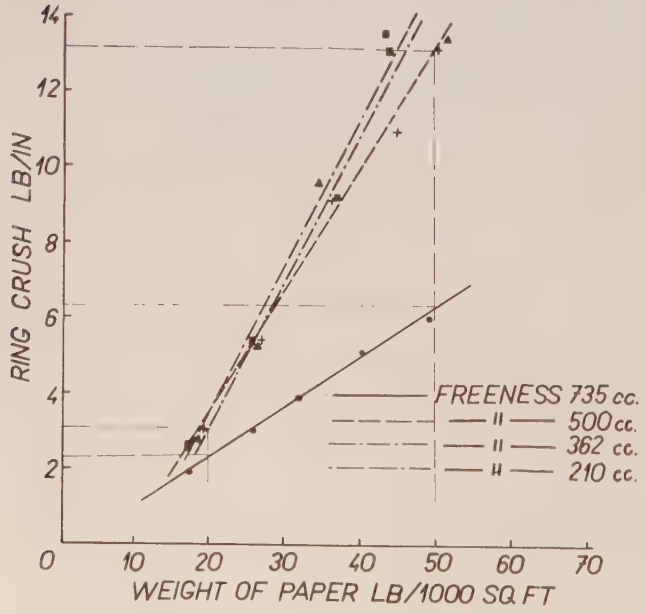

Fig. 1. Relationship between ring crush resistance basis weight, and freeness

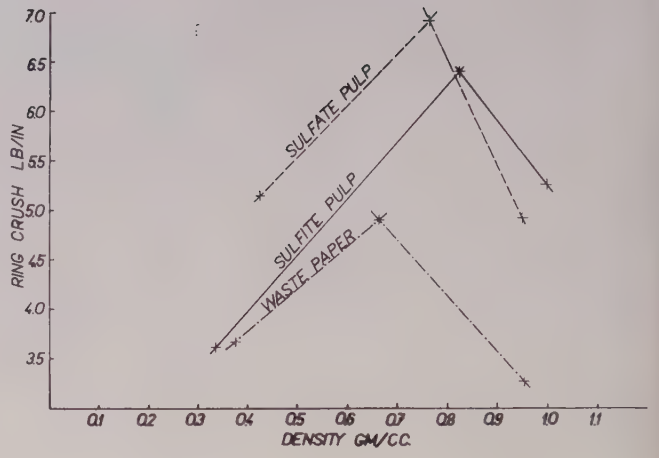

Fig. 5. Relationship between ring crush resistance and density

corrugating medium against its basis weight under different freeness conditions. We can see that the increasing rate for the ring crush resistance is much steeper for a beaten (500 ml. Canadian freeness) than for an unbeaten pulp. A sheet from unbeaten kraft pulp (735 ml. C.S.f.), basis weight 20 lb. per 1000 sq. ft. had a ring crush resistance of 2.3 lb. per in., whereas the sheet of 50 lb. per 1000 sq. ft. showed the ring crush resistance of 6.25 lb. per in.—a difference of 3.95 lb. per 1000 sq. ft. A beaten sheet from kraft pulp (500 ml. Canadian freeness), basis weight 20 lb. per 1000 sq. ft. had the ring crush resistance of 3.1 lb. per in. and a heavier sheet of 50 lb. per 1000 sq. ft. reached the ring crush resistance of 13.2 lb. per in. The difference (the ring crush increase) is much higher in the later case (i.e., 10.1 lb. per in.). A maximum increase of the ring crush resistance can therefore be obtained by increasing the basis weight of the sheets used only if a pulp beaten to 500 ml. C.S. freeness is used.

Effect of the Density (Bulk) of Paper

This relationship was studied with regard to its practical importance. It is known that the beating process decreases the freeness of a pulp, increases the density of paper, but at the same time the ring crush resistance is increased only to a limited extent. Moderate beating increases the ring crush resistance which attains a limiting maximum at about 500 ml. Canadian freeness. Further beating has no practical effect on the ring crush resistance. We thought therefore that it would be interesting to investigate the relationship between the ring crush resistance of a paper sheet and its density. It was immediately clear that this relationship would not be a linear one.

The tests were performed with some typical raw materials used for corrugating medium in Czechoslovakia during the last years: sulfite pulp, kraft pulp, and wastepaper stock. Both chemical pulps were beaten to 600 ml. Canadian freeness, the wastepaper was merely fiberized in a laboratory pulper. Laboratory sheets of the same basis weight (30.6 lb. per 1000 sq. ft.) and different densities were prepared on a Rapid-Köthen sheeter. First of all, we wished to investigate the effect of density in a rough orientative manner. We measured therefore the ring crush resistance at three different densities plotted in Fig. 5. First point represents an uncompressed sheet, such as obtained from the laboratory sheeter; its density is 0.3 to 0.4 g. per cc. Second and third points were obtained from compressed sheets with densities of 0.6 and 0.75 g. per cc. This rough comparison showed that there exists an important interdependence between the density and the ring crush resistance of paper. We therefore performed a second test series and investigated more particularly the ring crush resistance at different densities on a special paper used specifically for corrugated layer (furnish: 60%

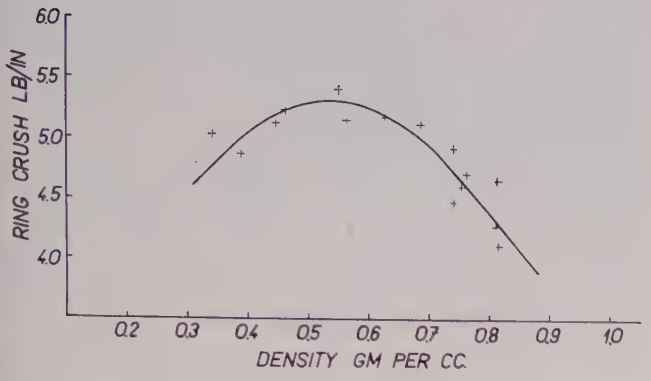

Fig. 6. Relationship of ring crush resistance and density

(Furnish for corrugating medium: 60% beech NSSC pulp, 40% mixed waste paper stock)

beech NSSC, 40% mixed wastepaper stock, both merely fiberized). By plotting our results graphically we obtained Fig. 6.

We can see that the ring crush resistance for this special corrugating medium attains a maximum at about 0.55 g. per cc. Higher densities affect the ring crush resistance adversely. Our results confirm similar experience of other authors (effect of the density on CLT-value).

Effect of the Pulp Freeness

A kraft pulp was beaten in a Valley laboratory beater to different freeness grades. Sheets were made on a laboratory Rapid-Kothen sheeter. After 24 hr. of conditioning the ring crush resistance was measured on a conventional apparatus. The maximum relative increase of ring crush resistance was noticed during the first phases of beating. Prolonged beating affects the ring crush resistance only insignificantly. Results are given in Fig. 4 and show that the optimum freeness value for maximum ring crush resistance lies in the neighborhood of 500 ml. C.S.f. The same results were obtained when using neutral sulfite semichemical hardwood pulp. A gentle beating treatment increases the ring crush resistance considerably, when compared with untreated, only defibered pulp (freeness about 735 ml. C.S.).

CONCLUSIONS

1. Because of the very high correlation coefficient between the ring crush resistance and the flat crush test (0.92), the ring crush test may be considered, under certain conditions, as a suitable criterion for evaluation of corrugating medium quality.

2. The study of interdependence between ring crush resistance and breaking strength (length) resulted in a very low correlation coefficient. The tensile strength (breaking length) of paper is therefore without any practical value for evaluation of corrugating medium.

3. The correlation between the bursting strength and tearing strength and ring crush resistance has coefficients of 0.83 and 0.74 respectively. This relationship has therefore only limited practical significance.

4. The ring crush resistance depends on the density (bulk) of paper. Maximum ring crush resistance was observed at 0.55 g. per cc. density. A further increase of density has a detrimental effect on the ring crush resistance.

5. Beating affects the ring crush resistance insofar the maximum value was obtained at 500 ml. Canadian Standard freeness.

6. There exists a linear relationship between the basis weight and ring crush resistance of paper (for the same stock and the same freeness). An increased basis weight brings about greater ring crush increase of semichemical sheets than of wastepaper stock. This increase is steeper when the pulp is slightly beaten to about 500 ml. C.S.f.

Asphalt and Its Use in Insulation Board

E. M. LORENZINI

A brief introductory review of the source and manufacture of petroleum asphalts with some emphasis on the basic characteristics, and their identification and modification. Comment on the pertinent properties of asphalt and the use in board for (1) hot surface application, (2) cold pulverized integral admixture, and (3) hot steam atomized admixture, including their general effects on board density, sizing, and strength. Brief review of the operational development of emulsified asphalt in the board industry, covering effects of coarse and fine dispersions. Discussion of the pertinent asphalt emulsion qualities effecting board formation, sizing, and strength. Conjunctive use of pulverized and emulsified asphalt. Conjunctive use of atomized and emulsified asphalt. Simple use of emulsified asphalt surface coatings at both the wet and dry ends of the board machine.

In a practical sense, there is nothing novel about asphalt; and by the same token, there is nothing novel in the function we seek to serve through the use of asphalt. Historically, asphalt is as old as primitive man, who seemingly has been making use of this material for the same basic purpose throughout the ages. You are all aware that the first crude protective seals against water and weather were made by early man with natural asphalt.

Today, in our modern concept, we look upon asphalt as a low cost thermoplastic derivative of petroleum. Our early cave man friend thought exactly the same thing—except that he didn't have the fancy words to describe his thoughts.

This long line of physical sameness in the end objectives is by no means an indictment of our ingenuity. The lure of the abundance and relative low cost of asphalt has been a spur to some rather fertile inventiveness, as witness the great progress in our waterproofing, building materials, and road construction industries.

We may be somewhat short in our component knowledge and strictly scientific understanding of asphalt, but nevertheless we have ingeniously employed great quantities with excellent results. The challenge, as always, is the emphasis on the economy. The petroleum industry gives us a low cost product, which we cannot pass up—so, for the benefit of those who may not be altogether conversant with the subject, let's have a closer look at asphalt, but bear in mind that this will be brief and elemental, and we can only touch on the high lights.

You are all aware that in the petroleum industry, "asphalt is the bottom of the barrel." This is a form of disparagement that can be cited as extreme oversimplification. We had better face the facts here at the very start, that the chemical composition of asphalt is extremely complex, and is the source of considerable controversy among competent asphalt technologists. In this presentation, however, we will be interested only in the elemental constituents which can be simply categorized and studied for their effects on the behavior of asphalt. Even in such a simple statement, you can find dissension among the experts. Here we intend to dwell only on the broad classic concepts to assist our better understanding of the physical applications in the insulation board usages.

We derive our principal supply of asphalt from crude petroleum. So-called waxy crudes, which contain principally the simple, straight-chain, paraffinic molecules, are not suitable sources of asphalt and not of interest in our present discussion. Our main interest originates in that type of crude petroleum containing extremely complex, high molecular

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weight aromatics and naphthenics. The residuum from the distillation of such crudes provide us with asphalt. For further generalization, ASTM defines asphalt as black to dark brown solid or semisolid cementitious material which gradually liquefies when heated, in which the predominating constituents are bitumen all of which occur in the solid or semisolid form in nature, or are obtained by refining petroleum, or which are combinations of the bitumens mentioned, with each other or with petroleum or derivatives thereof. Take notice of the broad physically descriptive words (a) dark color, (b) cementitious, and (c) heat susceptible, all with the key word bitumen. These are all simple words that reflect the more important physical properties that we seek in asphalt, such as water resistance, adhesiveness, stability, viscosity-temperature susceptibility, solubility, and other of the lesser sought physical characteristics.

Chemically, asphalts are a highly complex mixture of hydrocarbons, with widely varying molecular structure, depending on the source of the crude and the method of refining. Unfortunately, there is no simple approach to the determination of the composition. We have recourse mainly to empirical separations, for such studies, in which, incidentally, there is still considerable variance among competent asphalt chemists, as to the best method for making these separations.

For the elemental purposes of this presentation, we will remain with the classic separation of the constituents—namely, the asphaltenes, resins, and the oils. In this approach, a combination of polar character and molecular weight becomes the basis of differentiation.

Briefly, the asphaltenes are that fraction of asphalt which is precipitated in normal pentane or a similar low boiling saturated hydrocarbon. After filtering the asphaltenes, the solution is passed through a clay column. The resin fraction is adsorbed on the clay, while the oils pass through. The resin is removed from the clay by passing benzene-alcohol through the column.

Briefly, we can describe these components as follows. The oil is a white-to-yellow color, semifluid, and sticky with the lowest average molecular weight of the triad. The resin is a pale to dark brown color of heavier consistency and has an intermediate molecular weight. The asphaltenes are dark brown or black solid particles, soluble only in such solvent as benzol, chloroform, or carbon disulfide. The asphaltenes have the highest molecular weight.

An easy concept is an oil-resin-asphaltene sequence in which direction the molecules grow larger and the carbon-to-hydrogen ratio, reflecting aromaticity and polarity, all increase.

Continue to bear in mind that this classic separation is implemented through selective solvents and adsorption phenomena. It is the number and the nature of the separations of the oil-resin mixture wherein best light may be shed on the structure of asphalt. However, molecular weight classification of the oil-resin is not in itself enough and knowledge of the complex chemical interaction is necessary. There are two basic theories in contention. One is the colloidal suspension theory which assumes the asphaltenes are enveloped with adsorbed resins and the micelle thus formed is suspended in the oil medium. This colloidal theory is consistent with the non-Newtonian behavior of some asphalts.

The other is the solubility theory in which the asphaltenes are assumed to be dissolved in the oil-resin mixture and thus explains still other properties of asphalts that do not reflect colloidal behavior.

For sake of elemental simplicity, we will stay with the classic triad in which composite effects can be indicated very easily with a ternary graph, about which we will have more to say later.

The five types of processing generally employed in the recovery and refining of asphalt, and by which they are classified, are as follows:

1. Steam refined asphalt, in which steam is injected for the continuation of the initial distillation and thus drive off oils for further concentration and hardening.
2. Airblown asphalts, which are oxidized by air injection and achieve increasing hardness by decreasing the oil and increasing the resin and asphaltene components.
3. Vacuum flashing in which the heated residue is introduced into a separate column at lower pressure, and a portion of the oils are flashed off accomplishing the same result as in steam refining.
4. Solvent precipitated asphalt, obtained for example by propane extraction in which the resulting precipitation concentrates the resins and asphaltenes.
5. Cracked asphalt, the residuum from thermal cracking at high temperatures and pressures.

Although we have extended our knowledge considerably in recent years relative to the composition of asphalt, it remains of such complexity that we still prefer to establish identification by measurement of the physical properties as viewed along the lines of commercial uses. This takes the form of purely empirical tests conducted under standard conditions. The tests are definitive only for a specific condition, hence the single empirical measurement is not always broadly significant. For instance, we know that penetration or softening point measurements are, in effect, nothing more than single points on a viscosity curve. However, we employ these tests in certain relationships that reflect greater significance by virtue of giving some orientation to the curve in question.

The most important and elemental physical property of asphalt is its consistency, i.e., whether it be hard, soft, or fluid. We measure this by three empirical methods; one, the depth of vertical puncture into an asphalt at a specified temperature of a standardized needle bearing a specified weight. This we call the penetration which is an empirical measurement of hardness and resistance to flow. The second consistency test, the so-called softening point, is designed to reflect the melting characteristic which is not a sharp temperature point, since asphalt consists of many different components each in theory having its own melt point. The softening point is defined as the temperature at which the consistency of asphalt, placed in a standard brass ring, permits the passage of a standard steel ball to a depth of 1 in., while subjected to a specified rate of heat increase in a water bath. It is interesting to note that the softening point consistency represents a penetration of approximately 800, or a viscosity of about 1.2×10^4 poises.

The fluidity or viscosity of an asphalt has a practical application significance of which the changes are most important at elevated temperatures.

Viscosity is measured in a host of different standardized viscosimeters, of which the Saybolt Furol is one of the simplest and most popularly used. Incidentally, the new types of microviscosimeters are growing rapidly in usage. These viscosimeters employ the principle of thin films between glass plates in which rates of shear at various stresses are measured at different temperature levels. This has become an excellent research tool.

One of the most important physical characteristics of asphalt is the temperature susceptibility which reflects consistency or fluidity changes at different temperatures. This property is expressed generally as a ratio, or the rate of physical change for equivalent temperature change. For instance, if for any given asphalt we graph penetration values against their respective temperatures, the slope of the curve serves to indicate the temperature susceptibility. Even for asphalts from the same crude oil source, this simple slope relation changes with hardness or with the specific treatment of the asphalt. Such graphed results are not linear functions and we have a number of different mathematical approaches that are used such as penetration ratio, or penetration index, to give us a suitable susceptibility measure, and thus better identify this important asphalt characteristic.

All of these susceptibility measurements merely describe the viscosity-temperature relationship; in other words, the

slope of the curve when some function of viscosity is plotted against temperature.

At this point, we can return briefly for a look at the composition of asphalt and take note of what influence the separate components may have on the physical characteristics. The ternary graph is our best means of readily showing the physical effects of compositional changes.

You are all familiar with the accompanying triangular graph, which permits the ready plotting of three separate quantities in terms of related percentage that add up to 100%. The apices of the triangle show 100% of the specific component, and the center area more or less reflects equal presence of all the components. Therefore, movement in the direction of any apex shows predominance of that particular component.

As mentioned earlier, we are again looking at the basic classification of asphalt into oils, resins, and asphaltenes.

The graph, as we have shown it in Fig. 1., indicates the listed properties of the separate components and, of course, these different characteristics take prominence in their respective apex-areas of the graph. Movement of any plotted point, in the direction of an apex, simply accentuates that component.

For certain related properties we can think of a clockwise sequence on the chart, which in the order of oils, to resins, to asphaltenes, shows increasing molecular weight, and increasing polarity fromthe theoretically Newtonian behavior of straight oils to the nonfluid asphaltenes. Incidentally, in this concept it is the resins that fill the all-important gap and are the peptizing aid in stabilizing the dispersed asphaltenes.

This same classic direction toward high asphaltene content results in hardness and decreasing ductility.

The resin content plays an important role in the temperature susceptibility of an asphalt, as shown on the graph. This susceptibility property is pertinent in the internal use of asphalt in board, simply because we wish the asphalt to flow readily at elevated temperatures and thus properly envelop the fibers for stronger interattachment with each other. This, with hardness of the asphalt at normal temperatures, makes for better strength in the board as well as better water repellancy.

You will note the shaded area on the graph which gives preference to high resin content for asphalt to be used for internal board sizing. As is also shown, the resin is an important stabilizing link in gel-type asphalt of high asphaltenes. High resins create the sol-type asphalt.

As a matter of related interest, we have shown a separate shaded area in the graph for paving grade asphalt.

Before leaving the ternary graph, we can look quickly at the manner of influence on the compositional changes, resulting from the different refinery processes applied to any given charging stock.

It will be noted that air blowing brings about a net result of converting oils to asphaltenes; therefore, the directional movement on the graph is along the constant resin slope

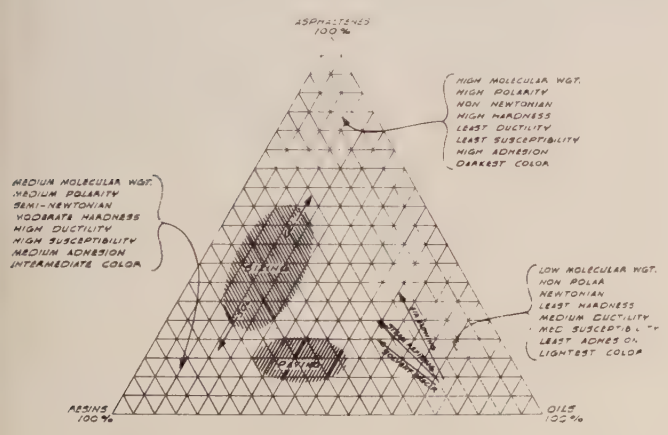


Fig. 1. Classification of asphalts by composition

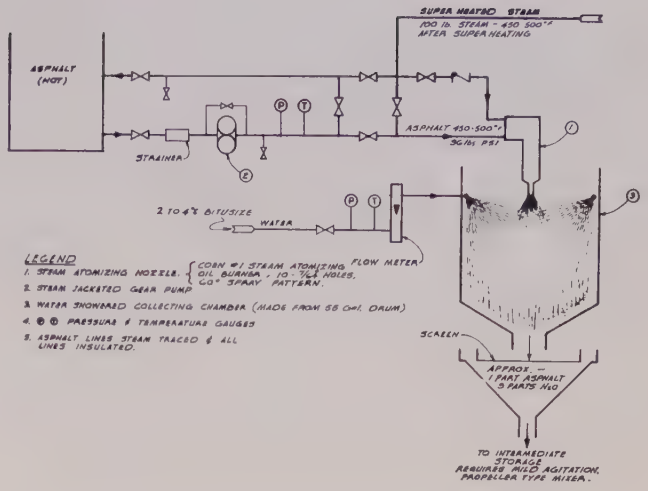

SUPER HEATED STEAM
100 lb. STEAM - 450-500°F AFTER SUPERHEATING
ASPHALT (HOT)
STRAINER
ASPHALT 450-500°F 30/40 PST
2 TO 4% BITUSIZE
WATER
SCREEN
APPROX. — 1 PART ASPHALT 5 PARTS H2O
TO INTERMEDIATE STORAGE REQUIRES MILD AGITATION. PROPELLER TYPE MIXER.
LEGEND
1. STEAM ATOMIZING NOZZLE. CORN #1 STEAM ATOMIZING OIL BURNER, 10 - 7/64 HOLES, 60° SPRAY PATTERN.
FLOW METER
2. STEAM JACKETED GEAR PUMP
3. WATER SHOWERED COLLECTING CHAMBER (MADE FROM 55 GAL. DRUM)
4. P T PRESSURE & TEMPERATURE GAUGES
5. ASPHALT LINES STEAM TRACED & ALL LINES INSULATED.

Fig. 2. Flow diagram—asphalt atomizing unit

toward the asphaltene apex. Steam refining moves us in the direction of resins because this process has the effect of concentrating resins by removal of oils. Solvent precipitation takes us faster in this same direction.

Before leaving the subject of asphalt composition with admitted attempt at simplification, please let me say there is no intention here to overstress resin as a complete answer to paperboard sizing. It is, however, one of the important factors.

We come now to the consideration of the various physical uses of asphalt in the soft board mills. We can touch only on the high lights, as we do not have the time, nor is it the purpose here to get into details.

From the point of view of its earliest and simplest uses, we can start briefly with a review of the hot asphalts generally employed for saturating and coating. This is such a established usage that it does not warrant any detailed review.

The saturants and light coatings are generally in a softening point range of from 150 to 160°F. and higher, with low penetrations at 77°F., in the range of 8 to 12, to give them the desired susceptibility for this usage. The flash points of such products are in the area of 550°F.

The heavy coating asphalt grades, for roof shingles, sidings, etc., are the airblown materials of less temperature susceptibility. The softening point range is usually 215 to 225°F. with a penetration of 15 to 20 at 77°F. and a flash point of 450 to 500.

The integral use of asphalt as a strengthening and sizing agent for insulation board is of more immediate interest to this group and is certainly a more challenging development for the boardmaker. The techniques were slow in their initial development, but the increasing competitive market for asphalted boards has lent a coniderable impetus to this progress and we find ourselves with present day, advanced board products, for which the design objectives have changed materially.

I believe the earliest attempts in the direct admixture of asphalt to fiber stock were made in steam-pressured autoclaves. These were in the nature of digestion chambers provided with some mixing or agitating device. The stock was steamed at high consistency, followed by direct admixture of hot liquid asphalt which afforded only a poor dispersion in the fiber stock. Actually, this was a continuous compromise between soft, readily dispersible asphalt which jeopardized the machine, or the choice of hard, nontacky asphalt, which hardened rapidly and could not be intimately mixed with the fiber.

The first successful heavy loading into a soft board was accomplished with a hard asphalt, finely comminuted in a cold slurry form. Today, we are all familiar with the high

softening point asphalt which takes the form of small pea sized chunks that are handled in bulk, and fed directly with water into ball mills or micropulverizers or hammer mills and thus achieve a wet ground suspended slurry.

Such asphalt has a softening point of approximately 240°F. with brittle and nontacky characteristics that permits easy fracture and no coalescence of the comminuted particles while abraded in a cold water slurry. The slurry is added directly to the fiber stock in amounts up to 20% by weight of asphalt on the dry fiber weight. This serves both as a filler and binder and increases board density with an appreciable increase in finished board strength. The asphalt of these coarse pulverized suspensions is too hard and coarse for true sizing action and a conventional sizing material is also required to achieve water repellency.

As an alternate method for cold pulverization, we now have hot atomization as a means of comminution. This is well out of the laboratory and into the field developmental stage and currently offers some attractive advantages, both in economics and handling.

The accompanying diagrammatic sketch (Fig. 2 shows the simplified operation of hot asphalt atomization, for subsequent admixture into fiber stock. The essential equipment consists of a hot asphalt storage tank, and an asphalt pump, together with a relatively inexpensive steam atomizing nozzle and a simple water showered collection chamber, as shown in the sketch. Control of asphalt and water feed rates, together with regulation of temperature and pressure permit the control of the finished atomized particle size.

The ratio of cold water to the hot asphalt becomes a key to the heat transfer and to the final temperature of the discharged water-suspended atomized asphalt. Only sufficient heat dissipation is required to bring the final mixture to a temperature below the coalescing point of the asphalt.

In our production scale runs thus far we have employed 235°F. softening point asphalt in a suspension of approximately 15% solids. The asphalt atomizing temperature is approximately 450°F. or higher and the temperature of the discharged mixture is approximately 110°F.

The finished atomized suspension is impounded in intermediate storage under mild mechanical agitation, and is added by regulated flow directly to the stock, up to 20% or more asphalt solids, based on the dry weight of the fiber.

This process offers flexibility in the employment of different asphalts and there is evidence that usage in a wider range of asphalt hardness will lead to a better control of certain properties in the finished high strength board.

At this point we can review the special types of asphalt emulsions that were first employed successfully in great quantities during the second World War. These are the stabile anionic chemical-type emulsions of approximately 200 softening point asphalts with emulsion particle size in the order of 1 to 3 μ.

Asphalt emulsions found ready acceptance in the soft board industry as a simple and efficient sizing and strengthening agent, without the formation and strength loss penalties of the earlier conventional sizings. Such emulsions provide increased board strength and high sizing efficiency, reflected in low water absorption.

Due to simplicity of operations, asphalt emulsions can be used economically up to 10% or more of asphalt solids, based on the dry fiber weight. At such elevated usage, emulsions provide good board strengths, but water drainage and slow formation become a handicap. This is due to the fineness of the asphalt emulsion particle which, during board formation, retards water drainage and thus results in slowness effects on the stock. This occurs mainly at the high asphalt content levels now being sought by the industry in so-called high strength board.

The sudden trend toward high asphalt content for high density board has brought both economic and performance pressures on emulsions, which has been met in part with lower cost emulsified asphalt. Currently, there is ample proof and recognition that emulsions do their best work at the low or moderate use range of asphalt, where we seek the electrochemical action of true sizing. However, economy motivates use of the coarser suspensions, whether pulverized or atomized, in the high asphalt loading, to achieve high board density and strength.

As a matter of further comparison and for the present,it can be said that emulsions and the coarser dispersions each occupy their own special niche in regard to suitability of their performance.

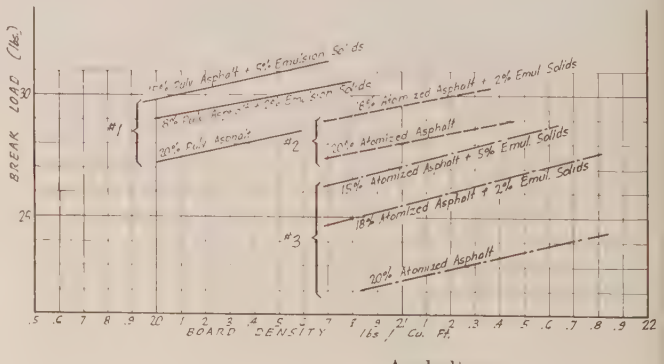
Some of the special characteristics are indicated in the accompanying graph, which is a hand sheet evaluation of the effect of board strength by the change in physical relations between coarse dispersions and emulsions. The three sets of "parallel-line" curves show the use of three different source asphalts, all of the same 235°F. softening point, but of different particle fineness, which in the legend are further briefly described as follows.

Asphalt no. 1 is micropulverized to a gradient containing 62% passing 200 mesh.
Asphalt no. 2 is steam atomized to a gradient containing 50% passing 200 mesh.
Asphalt no. 3 is similarly steam atomized, with 32% passing the 200 mesh.

In all the cases, the boards are designed witha total content of 20% asphalt, by weight on the dry fiber. There is the further division in which the coarse asphalt slurried dispersion and the asphalt emulsion are used conjunctively and intermixed in the proportions of 18 and 2% asphalt solids and 15 and 5% asphalt solids, respectively, thus maintaining a total of 20% asphalt in all the boards.

It is seen from the board strength curves (Fig. 3 that in all cases the small increment of asphalt emulsion, in conjunction with the coarse asphalt dispersion, serves to improve freeness and renders increased board strength, while holding the total asphalt content constant. This is not newly found phenomena. We believe that the emulsion serves as a dispersant, or possibly imparts a charge on the coarser particle, which improves its orientation with the fiber, and permits increased drainage with better board formation and strength. In other words, the emulsion gives an environment of surfactant action. This principle seems to open possibilities, particularly in the direction of increasing the total asphalt content, if the industry continues in this direction.

Before concluding with this strength graph, and although not here intended for such emphasis, it is interesting nevertheless to note the known influence of the fineness of dispersion which results in increased board strength. Moreover, the asphalt emulsion appears to lend most relative strength improvement to the coarser dispersion.


BREAK LOAD (lbs.)
30
20
#1
#2
#3
20% Pulv. Asphalt
20% Atomized Asphalt
15% Atomized Asphalt + 5% Emul. Solids
18% Atomized Asphalt + 2% Emul. Solids
20% Atomized Asphalt
.5 .6 .7 .8 .9 20 1 2 3 4 5 6 7 8 9 21 1 2 .3 .4 .5 .6 .7 .8 .9 22
BOARD DENSITY lbs / Cu. Ft.

Asphalt no.	1			2			3		
Type	Pulv.			Atom.			Atom.		
% Pass 200	62			50			32		
% Emuls. solids	0	2	5	0	2	0	2	5	
% Asphalt	20	18	15	20	18	20	18	15	
Drain time	35	40	37	27	30	28	30	34	

Fig. 3. Dispersant effect of emulsion on coarse suspension

One further item is worthy of mention in the usage of asphalt emulsions and that is the growing practice of roll coating directly on the wet board surface, upon emergence from the presses, at the wet end of the machine. The demand for asphalt coatings in both light and heavy application rates has given impetus to this simple low-cost method of surface coating on the top side of the sheet, which does not require secondary handling.

Asphalt emulsion is applied in the conventional roll-coating applicator, and the rate of the emulsion dilution serves as a control of the finished asphalt solids per unit of surface area. By virtue of the dilution and uniform filming, it is possible to achieve a continuous thin film in application rates down to $2^1/_2$ gal. per 1000 sq. ft. in surprisingly uniform coverage of 12 to 14 lb. of asphalt solids per 1000 sq. ft. Such extended coverage gives a good uniform black color, and good surface protection, but obviously is not capable of sustained barrier resistance. This requires a heavier application rate.

Asphalt emulsions can also be used in direct application to finished, dried board with conventional roll nips. The water phase of the emulsion is immediately flashed off by passage through a bank of direct flame-heated steel rolls, and with normal water spray cooling, the board can be stacked immediately.

In concluding these remarks, I would like to reiterate that we have purposely maintained the subject matter along rather generalized lines. We can all agree that the subject could be extremely lengthy if we were to get into details. As will have been noted, it was the intent rather to give some point and emphasis to some of the newer thinking and activity now prevailing in the industry.

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A Technique for the Evaluation of Starch as a Wet End Additive

JAMES R. WATERS

This paper presents a method for the determination of the retention of starch as a wet end additive. The colorimetric starch determination of Browning, Bublitz, and Baker has been modified to evaluate starch percentages in the headbox and paper. With this technique, paper mill evaluations were made enabling starch cost reductions to 25%.

Starch is an additive well known to the papermaker. In a discussion between papermakers, each one will have definite ideas as to why starch is used in the individual products. They present a number of reasons, such as strength, stiffness, finish, formation, sizing, rattle, and fuzz control, each being more or less important to the individual papermaker. When questioned as to how much starch should be used to achieve any one of these desired characteristics, the answers are equally varied. Most agree that starch is a very economical means of getting the desired characteristics.

Starch allows the papermaker latitude for the development of certain characteristics which if left to mechanical treatment alone might have to be sacrificed for others deemed more necessary.

Again, the starches available to the papermaker are as varied as his answers. Potato, corn, wheat, bean, tapioca, sorghum, and rice starches are available for his specific needs. He can purchase starches in as many varied forms as there are starches: high or low viscosity, raw, treated, pregelatinized, chlorinated, oxidized, partially dextrinized, or any combination of the above. The price of each starch and the increase in cost for modification of starch will also serve as a basis for choice. The price, type of starch, the form of that starch and the characteristics sought, confront the papermaker in his selection of the proper starch to use in his product.

When queried as to the retention of starches as a wet end additive, the answers again are as varied as the number of starches available. Strasser (*2*), when seeking information from the paper industry as to how much starch was retained to the fiber as an internal additive, received divergent replies. Some reported a high of 100% retained and others reported that if less than 2% were added to the fiber, nothing was retained.

In the past, efforts to determine the amount of starch present in paper have been long and tedious affairs, and they could only be performed by a well trained technician. In 1952, Browning, Bublitz, and Baker (*1*) presented a new method to the industry for the determination of starch in paper. The purpose of this paper is to present a technique which would be reliable in determining the retention of starch as it is added to the wet end of a paper machine. It is felt that this technique is relatively simple to perform, it is quick, a minimum of reagents is needed, and expensive instruments are not necessary.

In previous work on filler retention aids, it was found that the most reliable indication of filler retention was over the wire retention. That is, a quantitative determination of filler present in the paper over a quantitative determination of filler present in the headbox. The headbox was chosen over all other parts of the wet end because it was felt that whether or not full equilibrium in the system was attained, it would be representative of the wet end at that particular time and facilitate getting a paper sample representative of the prevailing conditions.

All titanium dioxide determinations made during the filler retention aid study were of the gravimetric, oxidized method using visual comparison of the color developed. Naturally, it was quite difficult to have two men agree on the exact color duplication. In an attempt to eliminate the errors produced through disagreement, an extensive amount of literature was acquired on colorimeters and spectrophotometers. Price was of the utmost importance, for at this time the instrument was to be used for one test only. In general, most reliable instruments cost $1000, or more. The Bausch and Lomb Optical Co. had just recently put on the market a colorimeter called the Spectronic 20, which retailed for less than $300. This instrument was consigned to the Gilbert Paper Co. on a 60-day trial basis. In subsequent tests, comparing visual analysis with instrument analysis, using a calibrating curve drawn for titanium dioxide determinations, it was proved that reliable and reproducible results could be achieved by several technicians. On this basis, the Spectronic 20 colorimeter was purchased and is the instrument currently being used for all colorimetric determinations at this company.

The simplicity of operation with this instrument is such that an inexperienced person could readily learn to operate it (Fig. 1). The procedure for making colorimetric determinations with the Spectronic 20 is as follows:

The wavelength control A is rotated until the desired wavelength is indicated on the wavelength scale B. The instrument is turned on with the amplifier control C. After a few minutes warm-up time, the amplifier control C is adjusted so that the meter needle reads 0 on the per cent transmittance scale D. The test tube containing the reference solution is then inserted in the sample holder E and the cover closed. The light control F is then adjusted until the meter reads 100 on the per cent transmittance scale D. The test specimen test tube is then inserted in place of the reference solution and the per cent transmittance value is read directly

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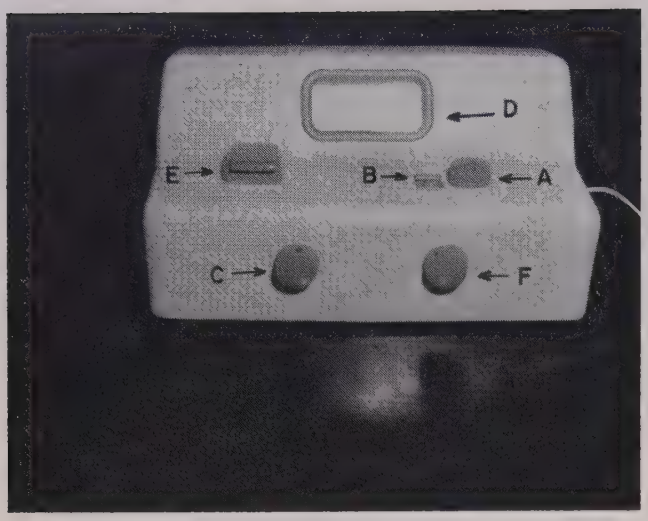

Fig. 1. Colorimeter

from the meter. This value is then related to predetermined calibration curves.

With this instrument and the colorimetric method of Browning, Bublitz, and Baker (*1*) it was felt that paper machine wet end starch equilibriums could be determined in an expedient manner. Their method was chosen over the TAPPI Standard T 419 m reducing method because of the simplicity in performing the test colorimetrically. The TAPPI Standard (*3*) appears to introduce variables and requires extreme care and patience to perform. The colorimetric method, using a minimum of reagents, quickly prepared, provided ease; and as we later learned, as high as 10 tests could be performed in one day by a single technician.

The Browning, Bublitz, and Baker method is as follows: "It is convenient to use paper which has been cut into 0.25 in. squares. Weigh out 0.25 to 0.50 g. (depending on the amount of starch present). Transfer to a 150-ml. beaker, add 100 ml. of hot water, and heat in a boiling water bath for 15 min. Macerate the paper frequently with a glass rod during this period. Decant the liquid through a coarse porosity fritted glass crucible with an asbestos mat, retaining as much as possible of the paper in the beaker. Wash the paper once with hot water through the filter.

"Add 25 ml. of 1:1 HCl at room temperature to the paper in the beaker and let stand with gentle maceration for exactly 2 min. Filter through the crucible previously used and receive the filtrate in the flask containing the water extract. Repeat the extraction with dilute acid. Finally, add 25 ml. of HCl to the paper in the beaker and let stand for exactly 20 sec. Filter immediately, transfer the paper to the crucible with wash water, and wash the paper with about 200 ml. of hot water.

"At this point, the paper may be tested for complete removal of starch by adding a few drops of very dilute iodine solution to the mat of fibers in the crucible. Normally, no color will be observed. Even a trace of residual starch will be evident from the appearance of the blue color.

"Cool the filtrate to about 20°C., transfer to a 500-ml. volumetric flask, and add 12.5 ml. of iodine reagent, and dilute to the mark. Determine the transmission or optical density with a suitable colorimeter. The reference cell contains a standard iodine solution as explained in the calibration procedure. The amount of starch is ascertained by reference to a predetermined calibration curve."

Using sampling techniques previously used for filler retention surveys, mill studies were made. The first error appeared to be in the extraction of the liquid sample. An excess of dissolved solids was being drawn into the test extract during the extractions. This was remedied somewhat by the substitution of a medium porosity fritted glass crucible for the coarse porosity crucible. When this substitution was made, enough of the turbidity was retained by the residual pulp mat so that the determinations appeared correct. Further work showed that this was the second error encountered. A fine porosity fritted glass crucible was substituted for the medium porosity crucible. Although this gave a clearer test extract, the time consumed for the extractions was so great that this method was discontinued and an investigation of turbidity in the test extract was made in the laboratory using the medium porosity crucible.

Table I. Turbidity versus Per Cent Light Transmittance

Starch, %	*% Transmittance* 2	4	6	8	10
Clear	88.0	76.5	65.0	56.5	49.0
10 p.p.mp TiO_2	87.0	76.5	65.0	56.0	49.0
20 p.p.m. TiO_2	87.5	77.0	64.0	56.0	50.0
20 p.p.m. Clay & 3 p.p.m. TiO_2	89.0	75.0	64.0	56.0	49.0

Test specimens were prepared in the laboratory using a known amount of filler, hereafter to be referred to as parts per million turbidity. The samples were checked colorimetrically in the presence of the iodine reagent and without the iodine reagent, to see if a correction factor could be applied. After extensive investigation, it was proved that this would necessitate a myriad of graphs and would present an additional source of error. A calibration curve would have to be drawn for each level of turbidity, as parts per million, and the error deduced from the final test reading.

This problem was then approached in a different manner. It was thought that if the turbidity of a test extract could be duplicated in the reference solution, a more true starch determination could be made. Of course, this would mean introducing an error to correct an error, but if the results could be duplicated, the end would justify the means. By introducing a known amount of titanium dioxide to distilled water in an equal proportion to that of a normal test extract, a calibration curve was drawn, as parts per million turbidity. Because of the flatness of a titanium dioxide measurement across the spectrum, the 580 mu wavelength as used in the starch determination, was used for the turbidity calibration curve (see Fig. 2).

It was felt that the only correction factor necessary was to compensate for any turbidity in the test extract with an equal amount of turbidity in the reference solution. Under this precept, test solutions containing 10 and 20 p.p.m. turbidity, with the reference solution being adjusted equally, were prepared. These results showed reproducible readings at 2, 4, 6, 8, and 10% starch (Table I).

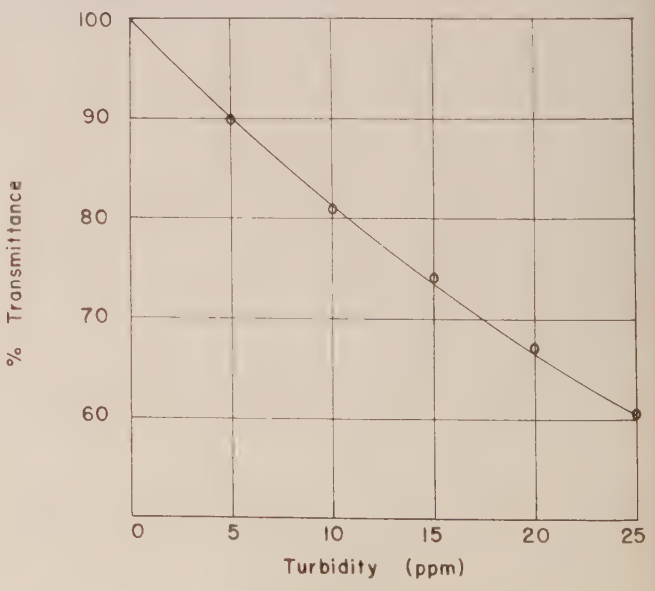

Fig. 2. Turbidity calibration curve

To correct for clay as turbidity the following experiment was made: 20 p.p.m. clay was added to a test sample. A measurement of light transmittance was made on the 580 mμ wavelength, using distilled water as a reference solution, and with no iodine reagent present in either solution. By referring to the calibration curve previously drawn for parts per million turbidity, it was learned that to equal the turbidity caused by the clay present in the test solution, titanium dioxide at 3 p.p.m. would have to be introduced to the reference solution. New solutions were made, using 20 p.p.m. clay in the test solutions and starch in the amounts of 2, 4, 6, 8, and 10%. The reference solution was brought to turbidity equilibrium with 3 p.p.m. TiO_2. The iodine reagent was then added and the light transmittance measurements made. This verified the thought that a starch calibration curve could be read directly if the same amount of turbidity were introduced to the reference solution as was present in the test extract (Table I).

After eliminating this error in test results, a procedure modified slightly in technique to that of Browning, Bublitz, and Baker (*1*) was devised. A representative sample was collected from the headbox of the paper machine. The consistency was determined and a wet sample, equal to 50 mg. of moisture free filterable solids was used as the test specimen. A graduated pipet, with the delivery end ground down so that there would be no restrictions in the capillary when wet stock was measured, was used for this purpose. The determined amount was added to a 250-ml. wide mouthed Erlenmeyer flask and brought to a 100 ml. volume with boiling distilled water. This was placed in a boiling water bath and stirred for 15 min. with a slush-type stirrer operating at approximately 150 r.p.m. After 15 min., the sample was quantitatively transferred to the medium porosity fritted glass crucible mounted on a 1-l. Buchner flask. Suction was applied and the Erlenmeyer flask washed with a minimum amount of boiling distilled water and transferred to the crucible. Two acid extractions were made with 25 ml. of 1:1 HCl for a period of 2 min. each, after which the acid was drawn, with suction, into the test extract. A final acid extraction, using 25 ml. of conc. HCl for a period of 20 sec., was made and drawn into the test extract with suction. The pulp mat was then washed with about 200 ml. of boiling distilled water and drawn into the test extract with suction. At this point, the residual pulp mat was checked for the removal of starch with a very dilute solution of iodine. As no blue starch-iodine stain was observed, the pulp mat was discarded and the test extract transferred to a 500-ml. volumetric flask. At this point, there was about 475 ml. of test extract in the flask. A measurement of turbidity was then made on the test extract, using distilled water as a reference solution. After the turbidity measurement was made, 10 ml. of conc. HCl was added to a 100-ml. volumetric flask and diluted with distilled water to about 85 ml. volume. Sufficient titanium dioxide slurry was then added to this reference solution so that the turbidity was equal to that present in the test extract. Both flasks were then cooled to 20°C., after which 12.5 ml. of iodine reagent was added to the test extract and 2.5 ml. of iodine reagent added to the reference solution. The solutions were then diluted to the mark with distilled water and light transmittance measurements were made. By referring to the proper calibration curve, this measurement was converted to per cent starch present in the headbox.

Again, to determine if the measurements being made were of sufficient accuracy as to determine mill policy, a series of

Table II

	Starch	
	Control	*Filtrate, %*
5% Clay	3.5	2.0
5% TiO_2	3.5	2.1
Flocculent	3.5	2.1

Table III. Typical Mill Survey
Three-bond, 20-lb. substance

	% Starch				
Starch	*Addition*	*Headbox*	*1st. Tray*	*Paper*	*% Retention*
Pearl Corn	3.8	14.0	66.0	1.32	9.45
Potato	2.05	7.5	51.4	2.0	26.7

laboratory tests was conducted. The experimental furnish consisted of cotton linters, rosin size, alum, clay, titanium dioxide, a high polymeric-type flocculant, and starch. To expedite this testing, a Buchner-type funnel was made out of stainless steel with a 100-wire mesh insert instead of the usual porcelain. The cotton linters were refined in a 5-lb. Valley beater at 2% consistency, to a 650 ml. Schopper-Riegler freeness. One per cent rosin size was added to the fiber and alum to a pH of 4.5. After 20 min. mixing time, the stock was diluted to $^1/_2$ of 1% consistency and the pH adjusted to 4.8 with alum. Sufficient aliquot parts of the diluted stock were measured, by weight, into three beakers so that there was enough stock for the forming of one 32-lb. substance handsheet, with sufficient stock left over to be used for control. To beaker no. 1 was added 5% clay. To beaker no. 2 was added 5% TiO_2. To beaker no. 3 was added the high polymeric-type flocculant in an amount equal to 0.4 lb. per ton of paper. The flocculant was used so that there would be as clear a filtrate in this test specimen as would be possible. Three and a half per cent starch was added to each individual beaker and mixed for 5 min. Dilute stock, equal to a 32-lb. substance handsheet, was then measured by weight from each beaker and the sheet formed in the Buchner-type funnel. The residual pulp mat was discarded and the filtrate collected. The remainder of each sample was checked for starch and used as a control. The filtrates collected were tested for starch present (Table II). When this again indicated that results of sufficient accuracy for mill evaluation could be made, another mill survey was planned.

The results of a typical mill survey are shown in Table III. These results compare cornstarch and potato starch as wet end additives. These results were obtained on one paper machine, under similar operating conditions. However, they are not intended to be conclusive evidence that one starch is better than the other, but merely an illustration of the knowledge that can be gained through an effective means of starch determination on the wet end of a paper machine.

In summary, the techniques as described in this paper have provided the Gilbert Paper Co. laboratory with a means of investigating the retention phenomena of starch as a wet end additive, not only on a laboratory scale but on a mill scale as well. With this method, the various starches available can be evaluated for the amounts required to produce the desired properties in the sheet, and starch cost evaluations can be accurately made. Although another starch or starch product is higher priced than that currently used, less may be needed to produce the required results and possibly reduce the annual cost of the starch purchased.

Through the investigations made at the Gilbert Paper Co., we have been able to evaluate the type and amounts of starch necessary for the desired properties, with surprising accuracy, ease, and speed. Because of the ease and speed of performing these tests, seasonal changes in starch retention have been observed and evaluated. As a result, we have been able to reduce starch consumption costs to this company in excess of 25%.

LITERATURE CITED

1. Browning, B. L., Bublitz, L. O., and Baker, P. S., *Tappi* 35, No. 9: 418–420 (1952).
2. Strasser, J. P., *Tech. Assoc. Papers* 20: 127–136 (1937).
3. TAPPI Standard T 419 m, Starch in Paper.

A C. J. West Memorial Award paper presented at the meeting of the Lake States Section of TAPPI, held in Menasha, Wis., April 11, 1961.

Double Effect Design Improvement in Pulp Screens

JOHN P. LARUE

Separation of acceptable and coarse fibers is accomplished in Cowan centrifugal pulp screens using these principles: (1) fiber alignment parallel to flow, (2) maximum alignment at periphery where flow rate is maximum, (3) rotating layer of high density pulp forms filter mat along periphery, (4) low density shives lag behind and flow axially to tailings discharge, and (5) higher density acceptable fibers pass through filter mat and screen plate perforations to accepted stock discharge. New Cowan K-Series centrifugal pulp screens operate at 100% increase in inlet consistency, 66% decrease in fiber rejects as compared to old series Cowan series. In principle, the new K-series screens replaces white water with feed pulp for dilution. An elongated and barrelled cylinder sharply increases the acceptable fiber for a given screen plate area. By retaining the water-carried fiber longer within the cylinder greater separation is accomplished. Savings at the intake end since input consistency can be higher by 100% it will need less water per ton of accepted fiber. Savings at the outlet end since reject fiber is decreased by two-thirds. Secondary screening can be drastically reduced or eliminated.

THROUGHOUT the pulp and paper mill processes we are continually working with or around physical laws and axioms. In order to achieve the desired end results the pulpmaker, the papermaker, the engineers, and the machine designers take these laws into account. Energy in one form or another is applied to the material to be processed in such a way that the matter assumes a desired composition, form, and appearance and possesses the required physical or chemical properties.

The object of screening pulp is to sort or separate coarse fibers or material from the fine acceptable fibers. The processing does not change the material physically or chemically but by classifying this material it greatly changes the properties of each fraction as compared to the characteristics of the material before screening. The energy applied to an unscreened mixture of pulp and water is entirely mechanical, making this a hydraulic process.

Separation of acceptable and coarse fibers is accomplished in the Cowan centrifugal pulp screen by using the following hydraulic principles.

1 Fibers in a mixture of pulp and water will align themselves nearly parallel to the direction of flow. The greater the velocity of the mixture the more parallel the alignment.

2 In a centrifically rotating mixture of pulp and water the maximum alignment will occur at the periphery, since the velocity at this point is greatest.

3 The denser fibers will move to the periphery from centrifugal force and low density material will lie behind, toward the center of the rotating element.

4 Acceptable fibers are equal or nearly equal in density to water. Coarse woody material and shives are lighter than water. Therefore, acceptable fibers will move toward the periphery but coarse fibers will stay closer to the center.

5. A rotating mat or layer of pulp having a density slightly higher than that of the inlet pulp forms at the periphery of the rotating element and acts as a filter medium. The thickness of this mat will increase directly with inlet consistency.

There are approximately 1200 Cowan screens in operation, largest portion of which are of the first model made—the Mark A. They are being used to screen practically every type of pulp made, including groundwood, hardwood and softwood sulfite, kraft, and semichemical, bagasse, bamboo, wastepaper furnish, and various others. Grades of pulp range from bond and dissolving to chip and roofing.

Figure 1 shows a cross section of the first model Cowan Screen to be used on a production basis, the Mark A. We will use this to show how the aforementioned principles are used to advantage to separate coarse material from acceptable fibers.

Unscreened pulp enters the screen through the inlet elbow (1) and is put into rotational and axial motion when it enters the primary section of the screen (2). Perforated screen plates (3) supported by frames form a cylinder around the rotor and the rotating mass of pulp. Acted upon by the rotor and the inlet feed forcing it into axial direction, the pulp moves spirally along the screen plates. Fiber alignment will be almost parallel to the plane of the holes in the screen plates. The mat of intermediate coarse fibers will form just inside the periphery. The higher the inlet consistency the thicker this mat will be, causing less fibers to pass through it and the screen plate perforations; the fibers that pass through

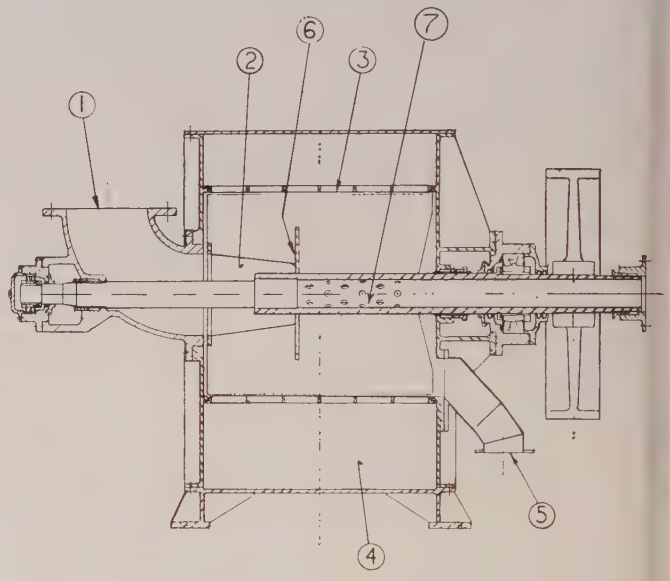

Fig. 1. Mark A lower Cowan Screen

the perforations leave through the accepted stock discharge (4). The rejects continue axially to the tailings discharge (5). The baffle (6) slows down the axial movement of the stock increasing retention time in the screen. The white water shower comes in through the center of the shaft and out through the center of the holes (7). This acts over the last three fifths of the screen plate area—toward the tailings end. Its purpose to dilute the rapidly thickening mixture and maintain uniform screening consistency over the entire screen plate area.

Since the Mark A, the following models of Cowan screens have been put into operation:

Mark E—scaled down version of the Mark A with about two thirds Mark A capacity.
Junior—further scaled down with about one third capacity of the Mark A.
K-300, K-400, and K-700—the new K-series design in sizes with capacities with 3000, 4000, and 7000 g.p.m., respectively.
KX-400—K-series with modified rotor for screening high yield pulps.
PS-300 and PS-500—for hot stock screening of kraft pulp.

Information on any of these models is available, but the balance of this presentation will be devoted to the K-series screens.

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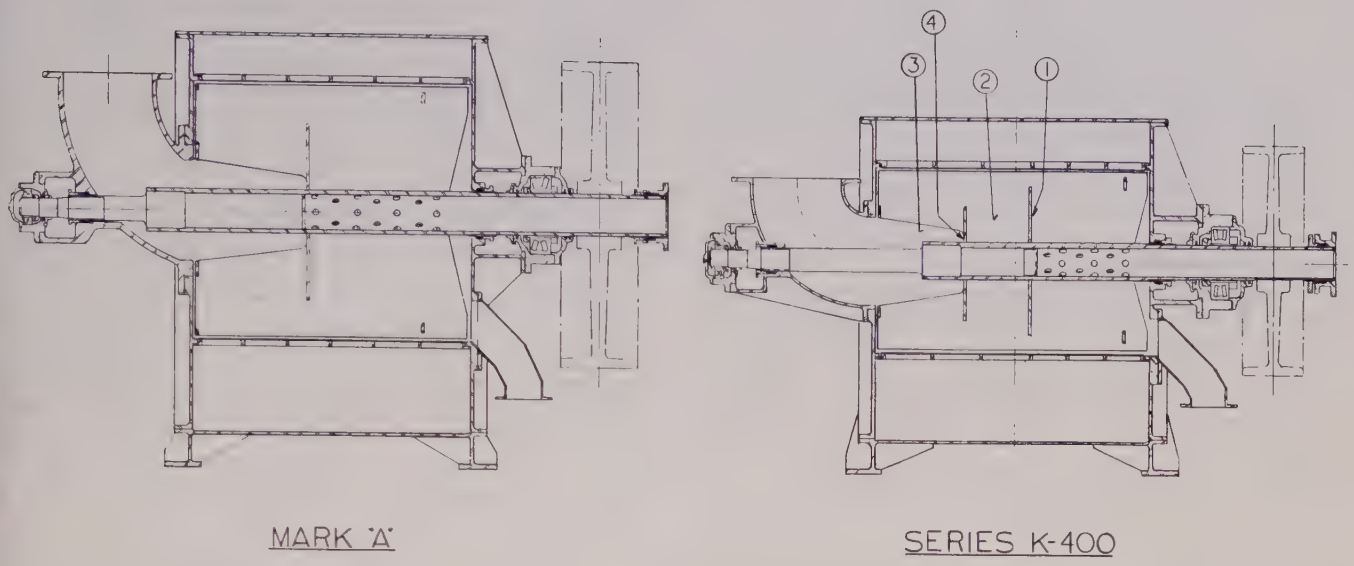

Fig. 2

NEW K-SERIES COWAN SCREENS

The new K-series Cowan screen is made in three sizes designated as K-300, K-400, and K-700. This design utilizes the principles of screening given before to a still greater extent than the earlier design Cowan screen. The benefits of over 15 years of operating experience with the older design Cowan screens have made this possible.

The K-300 screen corresponds to the Mark E and the K-400 to the Mark A. The design changes incorporated in the K-series screen have greatly benefited end results. In comparison to the older design screens the K-series give the following performance. (1) 10 to 20% greater capacity per screen, (2) 100% increase in screening consistency, (3) 66% decrease in fiber rejects, (4) improved accepted stock cleanliness, (5) lower horsepower per ton due to lower gallonage handled, and (6) smaller in physical size and less head space required.

Comparison of Design Features of Cowan K-400 and Mark A Screens

Figure 2 shows scale cross sections of Mark A and K-400 Cowan screens. The length of the K-400 is the same as the Mark A, but the diameter is less; therefore, the ratio of diameter to length is less with the K-series.

The revolutions per minute of the K-400 rotor is 340, that of the Mark A 240, however, the peripheral speed of each is the same.

It will be noted that the rotors of these two models are different. The K-400 has an extra baffle (1) and a third section in the rotor (2). Also, the white water shower is applied to less than one half of the screen plate area on the K-series screen.

Stock enters the K-series screen in the same manner as the earlier design Cowan screen. Most of the stock is directed out toward the periphery of the first section of the rotor (3). Some of the feed pulp, however, by-passes the first section and passes through ports (4) in the first baffle and flows into the second section of the rotor. This pulp at inlet consistency serves to dilute the material not accepted in the inlet section which passses over the first baffle. The pulp passing over this baffle will be dewatered and thickened until this dilution lowers the consistency to a point where further separation can be accomplished. As a consequence of this, shower dilution water is not required in either the first or second sections. The extra baffle and extra section also restrains the axial flow of stock to give added retention time and more complete fiber separation. Less shower water is required in the K-series and experience has shown it can screen at much higher consistencies than possible with the Mark A, Mark E, and Junior designs. This means less power per ton consumed by the screen itself and less pumping power to get feed pulp and white water to the screen. Due to the reduced volume of shower water required there is also less drop in consistency across the screen. With the K-series screen accepted stock consistency will be 80 to 90% of inlet consistency. In the older design, accepted stock consistency was 65 to 75% of inlet consistency.

The smaller diameter of the K-series permits more flexibility as regards to loading the screen. With the Mark A, it is necessary to operate at near capacity to maintain the rotating mass of dense pulp at the periphery of the rotating

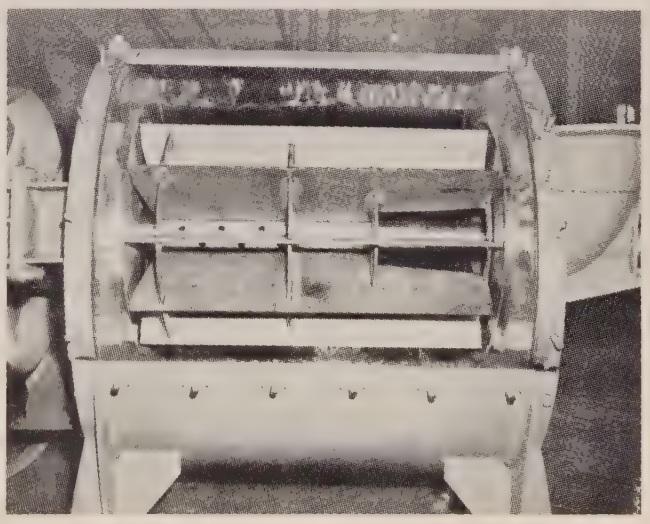

Fig. 3

element. Due to the smaller screen plate area the K-series can operate well at less than half load.

Figure 3 shows a K-400 screen in the frabricated stainless steel construction. The large components (end frames, base, and top cover) and frabricated of mild steel and lined with stainless. All other parts in contact with stock (inlet elbow, rotor, and shaft assembly, screen plate frames, screen plates, tailings discharge cover, and side covers) are solid stainless.

EFFECT OF SCREENING VARIABLES AND RESULTS

The variables that are normally controllable in the screening process are inlet consistency, feed tonnage, screen plate perforation size and pattern and shower volume. The latter should be adjusted so that the consistency all across the accepted stock discharge is uniform. Let us assume that this is done in every case and we will eliminate this variable.

All other things being equal, if inlet consistency is increased, accepted stock cleanliness will increase. Per cent rejects will also increase, horsepower per ton will be less, however.

Up to the point where the screen plates plug up, increasing consistency will increase the tonnage which can be put through

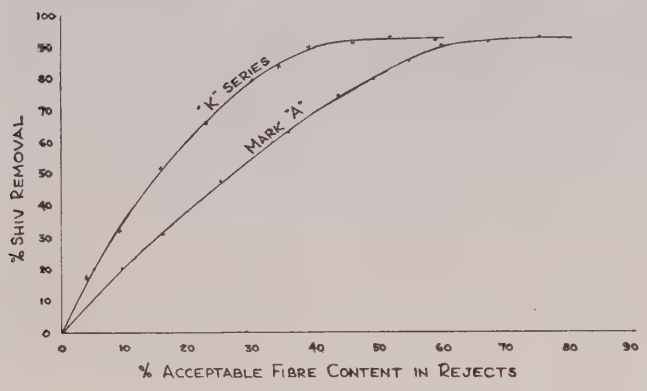

Fig. 4

the screen. Therefore it is advantageous to screen at as high a consistency as possible from standpoint of screen power per ton, pumping power per ton, and deckering following the screen.

If the screen plate perforation size is increased, the capacity of the screen will be increased and power per ton decreased. If this is the only change made, per cent rejects and cleanliness will both be lower. However, if at the same time both screen plate perforation size and inlet consistency are increased to hold the same per cent rejects, accepted stock quality will be as good with the larger perforations as was it with the smaller perforation size. In other words, accepted stock cleanliness with the Cowan screens will vary directly with per cent rejects regardless of whether this is controlled by hole size or consistency.

Of course there is a limit to this and this limit is established by experience on each type of pulp. That is, we could not get the required results on bond grade sulfite by increasing perforation size from 0.065 in. to $^1/_4$ in. and increasing inlet consistency from 0.9 to 3%. It might be possible, however, to improve the operation by increasing the hole diameter from 0.065 in. to 0.085 in., and inlet consistency to 1.25% and end up with equal accepted stock cleanliness.

It was said previously that accepted stock cleanliness varies directly with per cent rejects. This is not a straight line relationship and there is a point beyond which further increase in reject rate will have little effect on accepted stock quality. This being the case, there is no need in exceeding this optimum rate of rejects.

CONSISTENCY AS A FUNCTION OF SCREENING PROPERTIES OF THE PULP AND DEGREE OF SEPARATION REQUIRED

The actual consistency and required perforation size will depend on these screening requirements. Experience has shown that a rotating mass of pulp at consistency somewhat thicker than the inlet stock is formed at the periphery of the rotating element. The density and thickness of this rotating mass is dependent upon the inlet consistency and the amount of dilution water. As a large percentage of the debris contained in the tailings is small enough to be forced through the screen plate perforations under centrifugal force, it is apparent that the rotating layer of pulp functions as a screening medium. Excessive quantity of dilution water inside the screen will dilute this rotating layer of stock to a density lower than that of the inlet consistency. At this point across the screen plate area there will be a high acceptance of dirt and shives.

In the case of the K-series design the use of the inlet stock as partial dilution reduces the shower water requirement to maintain uniform screening consistency inside the screen. As the shower requirement will result in lower consistency drop through the screen with the K-series, it follows that the screening efficiency will be higher.

Figure 4 shows the relationship between per cent shive removal and per cent good fiber in the rejects for the old and K-series Cowan screens. With the Mark A, Mark E, and Junior models this optimum was approximately 60% good fiber in the rejects. With the K-series the per cent good fiber in the rejects for optimum cleanliness is in the 40% range.

MILL RESULTS—K-SERIES SCREENS

Following is given information with regard to K-series screens and three representative types of pulp.

Kraft. East Texas Pulp and Paper Co., Evadale, Tex., has two Cowan K-400 screens for primary screening of their entire pulp production before bleaching. Their pulp is a blend of pine and gum kraft in varying ratios. Throughput for each K-400 Screen when furnish is of primary pine kraft has been well over 250 A.D. tons per day with an inlet consistency above 2%. Per cent rejects is estimated to be under 5% and accepted stock cleanliness is equal or better than that obtained with previously used flat screens.

The Cowan screens are called upon to handle pulp that is blended of hardwood and pine. The percentage of each pulp is varied frequently and screening of the various blends are handled quite nicely by simple changes in consistency. This is quite an accomplishment since the screening characteristics of hardwood and softwood are quite different.

At Crossett Paper Mills, Crossett, Ark., a K-400 screen is operating alongside several Mark A primaries purchased several years ago. The K-400 is able to screen approximately 25% more tonnage than the Mark A's. It was also noted that when inlet consistency to the K-400 was over 1.6% and that of a Mark A less than 1% the per cent of good fiber in the rejects from the K-400 was considerably lower than those from the Mark A.

Sulfite. A sulfite mill engaged in the manufacture of dissolving grades uses three K-400 primaries and one K-300 secondary for their entire production. Tonnage throughput for each K-400 is 190 A.D. tons per day. Inlet consistency 1.1%, accepted stock consistency 0.9% and the reject rate from the primaries approximately 6%. Dirt count tests run right after startup showed a 40% reduction as compared to that previously obtained with the flat screens which the K-series Cowan replaced. Rejects from the secondary K-300 contained 300 lb. good fiber. Expressed as per cent of total production this amounts to 0.03%.

Groundwood. The first trial K series unit was installed in the groundwood mill of the Bowaters Southern Paper Corp. in Calhoun, Tenn. It was installed in the primary stage and was parallelled with their existing Mark A's.

Due to the physical layout the ability to measure flows accurately was not possible. No actual measurements were made during the trials of this screen at Calhoun and figures given below were estimated on the basis of visual observation. However, the installation was ideal for a comparison with the old design because the both types of screens were operating under identical conditions, the only variables being volumetric throughput and dilution water rate.

The capacity of the K-400 on this application was estimated to be at least 150 A.D. tons per day. At no time was there any apparent overloading of tendency to plug. The capacity of the Mark A screen is rated at 125 A.D. tons per day.

The rejects rate of the K-400 was estimated to be at least one third less than the Mark A screen. In both cases the feed consistency was approximately 1.25%. The accepted consistency of the Mark A was 0.90% and was approximately 0.95% for the K-400. The dilution water pressure on the Mark A was 4 lb. and $1^1/_2$ lb. on the K-400.

The results of this trial indicated that the K-400 has a higher unit capacity, higher capacity per screen plate area, lower power input per ton of accepted stock, lower shower water requirement, lower tailings rate, and lower good fiber content in rejects.

Under these operating conditions the K-400 screen was screening only a percentage of the total mill production. Since determination of accepted stock quality could only be made by sampling, the improvement in screening efficiency cannot be stated with any degree of accuracy. Comparison of hand sheets of the accepted stock did indicate, however, that the accepted stock from the K-series screen was cleaner.

Presented at the 46th Annual Meeting of the Technical Association of the Pulp and Paper Industry, held in New York, N. Y., Feb. 20–23, 1961.

Outfall Lines into Large Bodies of Water

WILLIAM PITTAM

The engineering problems involved in installing a submarine outfall line are discussed generally.

As THE title of this paper indicates, the information contained herein is of a very general nature, and no one is going to be able to design a submarine sewer outfall after reading the paper. However, the subject has never been generously dealt with in the literature and it needs more attention.

Historically it has nearly always been sufficient to pipe the effluent to the edge of the river, lake, or bay, consigning it to the large body of water without thought to dispersion or localized dilution factor. This obviated the necessity to construct anything more than a concrete spillway, or some type of cribbing to protect the end of the sewer line from damage from floating debris or shoreside cave-ins.

More recently, however, the growing attention given to pollution problems attendent upon effluent disposal has required more ingenious means of insuring that maximum dilution will occur, that foam will be minimized, and that water's edge conditions will not be intolerable.

In his approach to the engineering phase of constructing a submarine effluent discharge line, the engineer has a number of things to consider, among them being, bottom contour and subsurface conditions, currents and wave action, depth of water and hazards from shipping, and finally, materials of construction, particularly as they are affected by corrosion or the likelihood of flotation.

BOTTOM CONTOUR AND SUBSURFACE CONDITIONS

Provision of a bed for the effluent line is very important since the pipe should be uniformly supported along its length. Soundings to establish the contour of the bottom are a necessity and core drilling of any obstructions to be removed should be made. Often times this involves the use of a skin or suit diver, and limitations to the working depth of these divers must be considered and provided for. In some cases lines have been laid in trenches blasted in the bottom silt by hydraulic mining methods. In sandy bottoms where shifting sand bars might bury the pipe, piling bents can be driven and saddles can be provided to carry the pipe above the bottom thus allowing free movement of bottom materials under the line.

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CURRENTS AND WAVE ACTION

Perhaps it is trite to say that effluents are best dispersed where the current is strong, but it has a very important bearing upon the disposal problem. Effluents discharged into rivers obviously will be carried away by the current, but effluents discharged into lakes, tidal estuaries, and the ocean present special problems, particularly where the currents are very slow moving.

It is possible to map precisely the current pattern by the use of waterproof packets of yellow dye such as are used by the military to mark the location of ditched pilots. These packets can be suspended at the proper depth from small boats placed at the locations to be studied and released at a specified time. Aerial photos of the distribution patterns in a timed sequence can then be made using the proper camera filters for the purpose. It is amazing with what precision this can be done even at considerable depth. This method of following flow patterns is equally effective in studying flows after the line is in use. In this case the dye is introduced into the effluent pipe far enough above the discharge to insure good mixing.

Where, as in tidal estuaries, there is a reversible current, strong consideration should be given to impounding the effluent for discharge only at periods between high and low slack water.

Wave action is an important factor in location of an effluent line, particularly in large lakes or the ocean. First, it is necessary to provide the necessary structural strength to resist dislocation of the pipe during winter storms and second, wind and waves tend to produce an on-shore current on the surface which may return the effluent to the beach and thereby defeat the whole scheme for proper distribution.

DEPTH OF WATER AND HAZARDS FROM SHIPPING

It is axiomatic that effluent lines be deep enough not to constitute a hazard to shipping. In shallow waters it may be necessary to bury the pipe and use short lengths of plastic or rubber hose as nozzles to project above the bottom. Small craft accidentally encountering these flexible nozzles will not have their planks or propellors damaged.

The site of an effluent line is often marked by one or more piling dolphins on which warning signs are placed. These dolphins themselves constitute a hazard to shipping and may have to be lighted. Where the line is laid in navigable waters, the Army Engineers have jurisdiction and all plans and specifications must be reviewed by them in advance of construction, and prior approval obtained.

MATERIALS OF CONSTRUCTION

Almost any material from which pipe is made has been used for submarine effluent pipes at some time or another. Wood, stainless steel, or rubber-covered pipe can be used. Each has its advantages and disadvantages particularly when exposed to salt water. Prestressed concrete pipe and wood pipe are often used, and it is interesting to note that a prominent manufacturer of wood stave pipe developed an ingenious wood clamp in order to eliminate the steel bands normally used with this type pipe. Smaller diameter concrete pipe does not float, while precautions against floating must be taken against larger diameters of concrete pipe and all wood, or light gage metal pipe.

In conclusion, the considerations outlined above must all be taken into account when laying out a submarine effluent line. Local conditions will always pose other obstacles. An engineer is practically on his own, since the literature is not very outspoken on the subject. It is possible that a survey of this field will be undertaken by some person on this committee in times to come. Such a survey would undoubtedly be very helpful to the engineer faced with the problems of designing an effluent line.

Presented at the Fifteenth Engineering Conference of the Technical Association of the Pulp and Paper Industry, held in Jacksonville, Fla., Oct. 23–27, 1960.

Properties and Performance of Reinforced Polyester Plastics

R. E. GACKENBACH

The term "polyester" is a generic expression that represents a large family of resins which are used in the production of a much larger range of end products. Most polyester plastics are not used alone but in combination with a reinforcing material. Properties are given for a typical glass reinforced polyester plastic and graphs are presented showing the resistance to several solutions. However, laboratory data should be supplemented with field tests for specific applications.

It has been estimated that corrosion costs American industry in excess of 6 billion dollars a year. Every process industry is continually plagued by corrosion which promotes failures and breakdown of process equipment. Therefore, each process plant employs a staff of maintenance and engineering personnel whose function is to keep the production facilities in operational condition. The maintenance staff is mainly concerned with the making of day-to-day repairs whereas the engineering group is normally engaged in finding new solutions to old problems. Both groups, in turn, are vitally interested in the newer materials of construction, and in new uses for the older and more commonly employed materials.

Plastic materials have been known for almost a century; however, it was not until 1909 that the first real industrial plastic (phenol-formaldehyde) became available. Since then the plastics industry has grown in volume and in variety. The pace was greatly accelerated during the war years by the shortage of metallic materials of construction. Plastics were originally used on a substitution basis and, when the conflict was over, they had fully entrenched themselves in industry. In the beginning, the growth rate for reinforced plastics was slow. Both the fabricator and the ultimate consumer were cautious and conservative in designing, building and using these materials in corrosive environments. Today, plastics are being used to lower corrosion and maintenance costs and are now being accepted as a standard material of construction for the process industries.

Among the most versatile plastics in use today are the reinforced polyesters. The term "polyester" is a generic expression that represents a large family of resins which are used in the production of a much larger range of end products—polyester plastics. The basic polyester resins are condensation products of a dibasic acid and a polyhydric alcohol. The unsaturated products are cross linked with other materials, such as styrene, and are cured with selected catalysts, such as benzoyl peroxide and methyl-ethylketone peroxide. The final cured products are hard, brittle thermosetting plastics which harden as a result of an irreversible chemical reaction to give a product which cannot be softened upon reheating. Polyester plastics are formulated to achieve an extensive range of properties and characteristics such as resistance to chemicals and gases, heat, fire, electricity, and impact. Since our greatest concern is with the corrosive environments existing in the paper and pulp industry, this paper will be limited to those polyesters compounded for these applications. Early experience has shown that the standard polyester plastics were not adequate for chemical use.

Most polyester plastics are not used alone but in combination with a reinforcing material. Depending on form and arrangement, the reinforcing agent greatly influences the final physical and mechanical properties of the cured product and, in addition, helps to determine the best method of fabrication. For most purposes, the polyesters are reinforced with 25 to 35% by weight of glass mat, cloth, rovings, or rope. Since glass is attacked by hydrofluoric acid and its salts, synthetic fibers are substituted in those polyester plastics handling solutions containing these aggressive chemicals. For reasons of economy, a composite structure is often utilized. In these cases, glass reinforcemen is employed as the main reinforcing material and those surfaces in contact with the harmful solution are overlayed with a layer of synthetic fiber and a gel coat of plastic. When service conditions require, other fillers and pigmentation are added. With such a complex material it is virtually impossible to define the best polyester formula. Through experience, each fabricator has developed his own particular formula and the techniques required in its utilization. Unfortunately, there is no such thing as a standard formula or a standard nomenclature system. Each manufacturer of resin and each fabricator of polyester laminates have their own trade name.

Plastic structures for the process industries are made by hand laminating, either over mandrels or in molds. Multiple layers of glass fiber are impregnated with the mixed polyester resin, additives, and catalyst and cured at room or at elevated temperatures with little or no external pressure. The form and arrangement of the glass fibers produce an excellent bond so that the layers lose their separate identity and form a homogeneous product such that delamination seldom occurs. The laminates are normally of uniform thickness and density and free of voids, cracks, crazing, and dry spots. The edges of the various layers of reinforcement are staggered and overlapped. The surfaces in contact with the corrosive media are smooth and have no exposed glass; the external surfaces are reasonably smooth and free of exposed glass. All cut edges are coated with resin to prevent wicking or seepage along the fibers. In the absence of pigmentation, a difference in amount of light transmission through the plastic will reveal nonuniformities. The structure under fabrication can be made in one piece or in several sections. The sections are either field or shop joined by flanging or cementing with polyester resin and glass mat. The cementing method of joining is readily modified to serve as a method for field-repairing of damaged structures.

Polyester glass laminates are characterized by their light weight, which is 1/3 to 1/4 that of carbon steel; the specific gravity ranges from 1.3 to 2.1, depending on the amount and form of the reinforcement. The dimensional stability is good. The coefficient of thermal expansion is relatively low, and cold-flow is nonexistent. The thermal conductivity is very low and the dielectric characteristics are good; properly compounded polyesters are excellent insulators against heat and electricity. Most polyesters are combustible; the rate of burning is directly proportional to the styrene content. Certain grades can be made self-extinguishing and fire retardant. The rate of water absorption is low and resistance to vapor transmission is excellent. Typical physical and mechanical properties are shown in Table I.

Table I. Typical Properties of Glass Reinforced Polyester Plastic

Physical Properties	
Specific gravity	1.5
Thermal conductivity, B.t.u./sq. ft./hr./(°F./ft.)	0.15
Thermal expansion, in./in./°F. $\times 10^{-5}$	2.7
Specific heat, B.t.u./lb./°F.	0.30
Water absorption, % in 24 hr.	0.2
Mechanical Properties	
Tensile strength, 1000 p.s.i.	8– 12
Compressive strength, 1000 p.s.i.	25– 30
Flexural strength, 1000 p.s.i.	22– 30
Izod impact, ft. lb./in.	12– 16
Rockwell hardness, Scale M	90–100
Elongation, %	3– 5
Modulus of elasticity, 10^5 p.s.i.	12– 14

R. E. Gackenbach, American Cyanamid Co., Engineering & Construction Division, New York, N. Y.

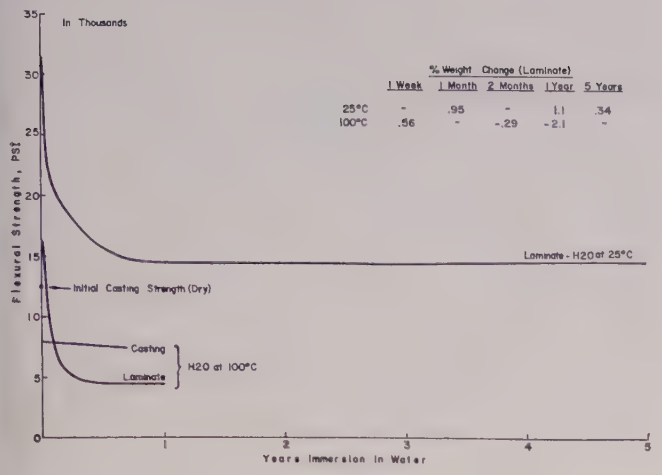
In Thousands
% Weight Change (Laminate)
1 Week 1 Month 2 Months 1 Year 5 Years
25°C - .95 - 1.1 .34
100°C .56 - -.29 -2.1 -
Flexural Strength, PSI
Laminate - H20 at 25°C
Initial Casting Strength (Dry)
Casting
Laminate
H20 at 100°C
Years Immersion in Water

Fig. 1

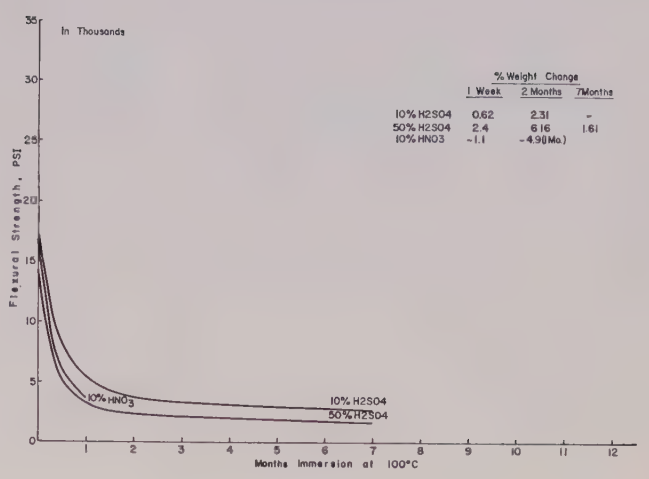

Fig. 2b

Reinforced polyester laminates are stronger than wood and approach the strength of soft carbon steel. For a plastic material, the tensile strength is high and directly proportional to the glass content. In some formulations, the tensile value is as high as 80,000 p.s.i. although 10,000 p.s.i. is most common for those grades used in process equipment. The weight to strength ratio is also very high; thus, on a pound for pound basis, reinforced polyester plastics are definitely stronger than steel. The compressive strength is generally 2 to $2^1/_2$ times the tensile strength while the flexural strength varies from 20,000 to 60,000 p.s.i. The cured glass-plastic laminate is tough and possesses high impact resistance; it withstands considerable mechanical abuse and shock. Although the material is hard and has a glassy appearance, it does not shatter like glass; instead, the laminate crazes and becomes opaque. In service, polyester plastics are unaffected by thermal shock or sustained temperatures up to 225°F. and intermittent temperatures up to 275°F.

Upon immersion in water or a chemical solution, a glass-reinforced polyester laminate suffers some loss of tensile strength and flexural strength. In the beginning, the loss over a relatively short time is quite high but, after the initial drop, the strengths remain fairly constant on continued exposure. For each solution, there is a family of curves; one curve for every temperature of exposure. There are also differences for the various combinations of resins and reinforcement.

American Cyanamid Company decided to study this phenomena; therefore, over 5 years ago, a 10-year test program was initiated. Laminates $^1/_8$ in.-thick were prepared from a chemical resistant polyester and 2-oz. glass mat with no added fillers. The laminates were press-cured at room temperature using a 2% peroxide paste and a 0.1% diethyl-aniline catalyst system; this was followed with a postcure at 250°F. for 2 hr. The effects of the chemical solutions on the laminates were determined by weight changes after immersion and by changes in flexural strength according to ASTM test procedure D-790. Long-time tests were carried out in various solutions at 77°F. and short-time tests at 212°F., or at reflux.

In the weight-change tests, a weight loss indicates that erosion, leaching, or extraction of the laminate has occurred whereas a weight increase indicates absorption of the solution by the laminate. For each solution, the same specimen was used throughout the test. The specimens were initially weighed while dry; however, after immersion and before immediate reweighing, they were only dried with a cloth to remove excess solution. Periodically, the solutions were changed to maintain purity and concentration. The initial flexural strengths in the immersion tests were taken after 24 hr. immersion in the test solution at 77°F. and after $^1/_2$ hr. immersion in boiling water at 212°F. During the test, all flexural strengths were determined not on dry samples but in water at either 77 or 212°F., depending on the test temperature. Since the edges of the test laminates were not sealed and, therefore, suffered from solution penetration, the outside $^1/_2$ in. of the panel was cut off before any flexural strength specimens were cut. Thus, the test specimens were free of any edge penetration effect and gave a true indication of the change in flexural strength.

Figure 1 shows the effect of water immersion on a reinforced polyester laminate and on a nonreinforced polyester casting. The casting suffered minor attack upon exposure to boiling water; the main effect is the rapid drop in flexural strength due to heating to 212°F. Upon drying after immersion, the

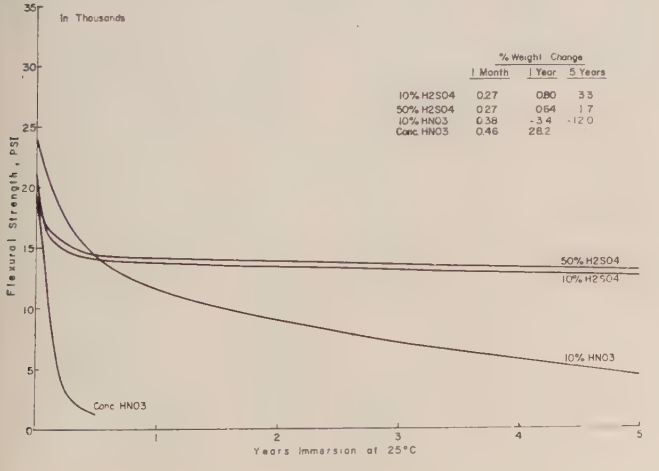

Fig. 2a

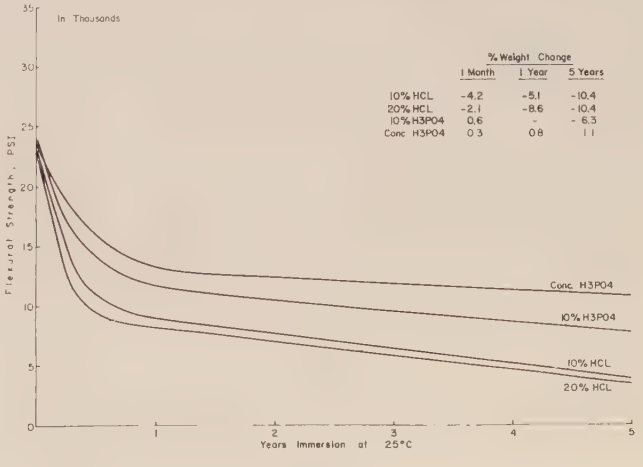

Fig. 3a

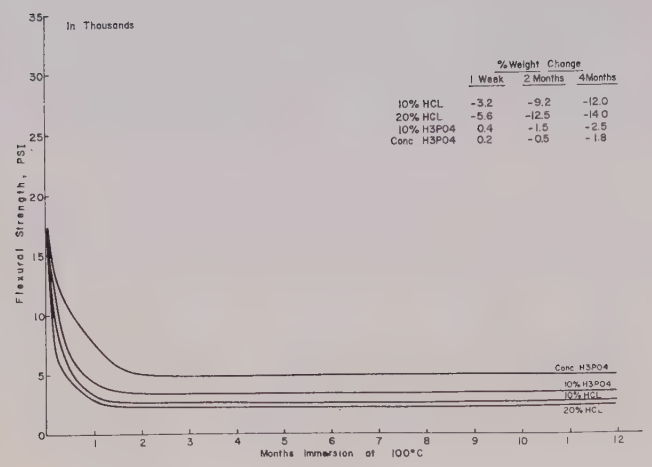

Fig. 3b

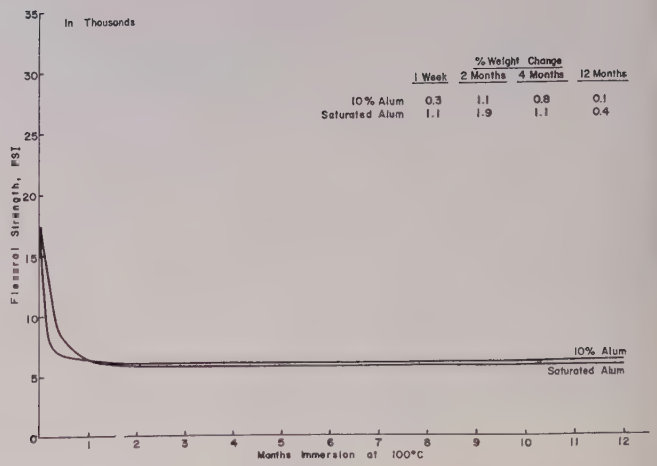
In Thousands
% Weight Change
1 Week 2 Months 4 Months 12 Months
10% Alum 0.3 1.1 0.8 0.1
Saturated Alum 1.1 1.9 1.1 0.4
Flexural Strength, PSI
10% Alum
Saturated Alum
Months Immersion at 100°C

Fig. 4b

casting recovered over 90% of its initial flexural strength; this can be considered complete recovery. The flexural strength of the laminate at 77°F. drops off rapidly in the first six months and then quickly levels off to a constant value. The test specimen at 212°F. suffered a greater loss. However, the two curves have the same general characteristics. After immersion in boiling water, the glass-polyester laminate does not completely recover its flexural strength. The difference in behavior between the unreinforced casting and the reinforced laminate indicates that a large portion of the strength loss of the laminate is caused by the weakening and destruction of the bond between the plastic and the glass. The weight change measurements reveal a slight absorption at 77°F. and a minor extraction at 212°F. The laminate, thus, suffered no real chemical degradation.

Figures 2a to 3b show the effects of sulfuric, nitric, phosphoric and hydrochloric acids. Polyester-glass has excellent resistance to sulfuric acid at concentrations up to 50% and at 77°F. Increasing the temperature to 212°F. promotes a rapid fall off in flexural strength and a significant loss in weight. Greater concentrations of sulfuric acid cause degradation of the laminate. Nitric acid, a strong oxidizing acid, in all concentrations at room and elevated temperatures is very detrimental to the laminate. Even after 5 years, there is still a dropping off in flexural strength at 77°F. Weight losses of the exposed specimens are high; the leaching and extraction has been appreciable. Phosphoric acid appears less harmful than hydrochloric acid in both the flexural-strength test and the weight-change test. However, the reinforced laminate still shows retention of strength for use with hydrochloric acid.

Alum (aluminum sulfate) which is widely used in papermaking has little or no effect on polyester-glass laminates. Figures 4a and 4b show there is a little gain in weight. At 77°F. the drop in strength is minor, whereas at 212°F. the drop is appreciable but still less than that shown for most of the mineral acids.

The alkalies are harmful to polyester laminates. As shown in Figs. 5a and 5b, 10 and 30% caustic (sodium hydroxide) at room temperature cause a rapid continuing drop in flexural strength. At elevated temperatures, the effect is more pronounced; the strength drastically decreases in a period of one month. Even the weight losses at elevated temperatures are phenomenal.

Organic chemicals as a group do not have any profound effect on chemical resistant grades of polyester plastic. Figures 6a, 6b, and 7 give the results of immersion in some common organic acids and solvents. The dilute organic acids promote a minor change in weight and loss of strength. In glacial acetic acid at room temperature, there is an appreciable increase in weight whereas there is but a minor increase at reflux. The solvents promote a minor drop in flexural strength and an appreciable increase in weight.

From these tests and corresponding field experience, several generalizations can be made. Polyester-glass laminates possess good aging and weathering characteristics; continuous outdoor exposure, both in the northern and southern sections of our country, does not adversely affect the cured plastic. Fresh, brackish and sea water have little or no effect. At room temperature, the resistance to dilute and moderate concentrations of non-oxidizing mineral acids is excellent, whereas, at elevated temperatures, the resistance is rated as only good. Hydrofluoric and hydrochloric acids are almost identical in their effect on the unreinforced plastic. However, glass reinforcement is rapidly attacked by hydrofluoric acid and its salts; therefore, synthetic fibers must be substituted in the

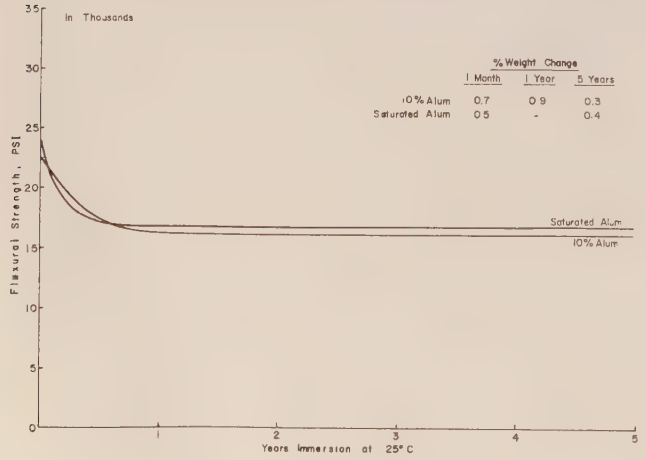

Fig. 4a

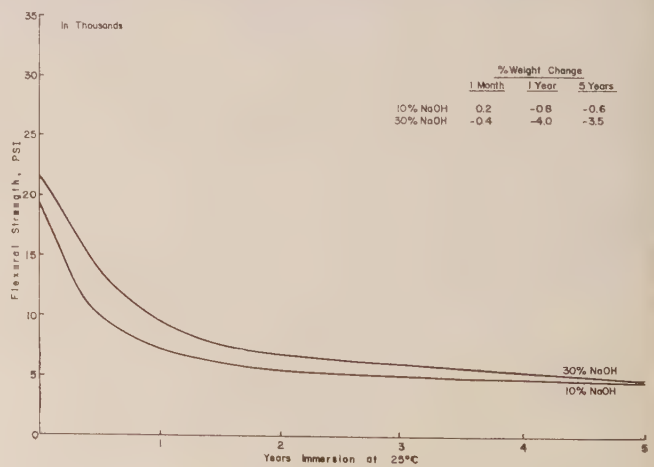

Fig. 5a

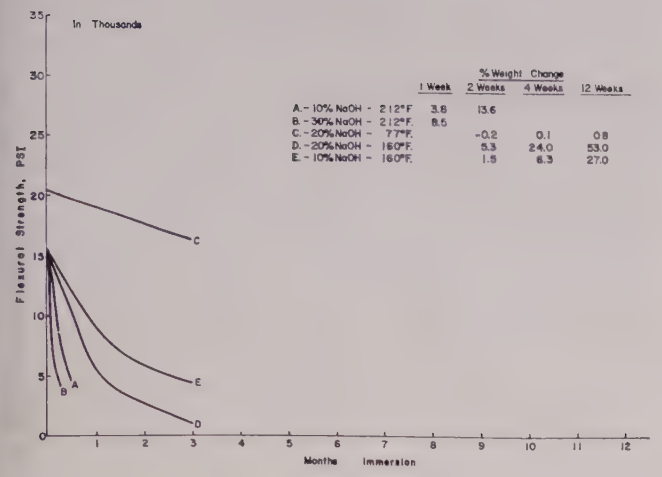
In Thousands
Flexural Strength, PSI
Months Immersion
% Weight Change
1 Week 2 Weeks 4 Weeks 12 Weeks
A.- 10% NaOH - 212°F 3.8 13.6
B.- 30% NaOH - 212°F. 8.5
C.- 20% NaOH - 77°F. -0.2 0.1 0.8
D.- 20% NaOH - 160°F. 5.3 24.0 53.0
E.- 10% NaOH - 160°F. 1.5 6.3 27.0

Fig. 5b

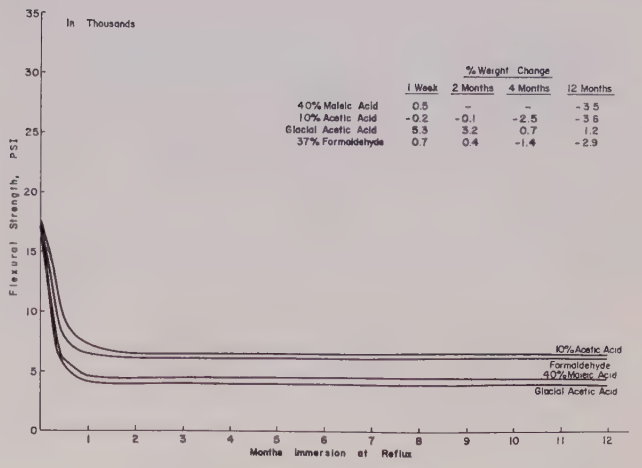
In Thousands
Flexural Strength, PSI
Months Immersion at Reflux
% Weight Change
1 Week 2 Months 4 Months 12 Months
40% Maleic Acid 0.5 - - -3.5
10% Acetic Acid -0.2 -0.1 -2.5 -3.6
Glacial Acetic Acid 5.3 3.2 0.7 1.2
37% Formaldehyde 0.7 0.4 -1.4 -2.9
10% Acetic Acid
Formaldehyde
40% Maleic Acid
Glacial Acetic Acid

Fig. 6b

laminates for those applications involving these media. The oxidizing acids are harmful and only the dilute solutions can be handled. Polyester plastics, however, are more resistant to dilute chromic acid, dilute nitric acid, sodium hypochlorite and other oxidizing media than either the phenolics, the furanes or the epoxides. Concentrated sulfuric acid, concentrated nitric acid, gaseous chlorine, and hydrogen peroxide promote deterioration; this effect is most pronounced at 200°F.

Salt solutions normally are less aggressive than the acid from which they are derived. Chlorides, sulfates, phosphates, cyanides have no detrimental effect; on the other hand, the oxidizing salts such as nitrates are borderline and some attack may be anticipated.

The alkaline resistance of reinforced polyesters is poor. The strong hydroxides not only attack the polyester but the glass as well. Only dilute concentrations at room temperature can be tolerated; as the temperature is raised, the allowable concentration must be reduced. The mild alkaline salts, carbonates in particular, have no harmful effect.

Glass-reinforced polyester plastic is suitable for many applications involving organic chemicals. The performance in fatty acids, aliphatic solvents, straight-chain paraffins, alcohol, and formaldehyde is good. Although aromatic solvents are safely handled at room temperature, some solvent action occurs at elevated temperatures. The chlorinated hydrocarbons cause softening and degradation.

In determining suitability for a given environment, both the polyester and the reinforcing agent must be considered. Polyester has better chemical resistance than the glass normally used in producing laminates. Organic chemicals promote attack on polyester plastic whereas inorganic chemicals hasten attack on glass. Unlike metals which are corroded at a specific rate, plastics are usually resistant or not resistant. When a glass reinforced polyester laminate is shown to be resistant to a certain chemical media at a specific temperature and concentration, it can be assumed that it is also resistant to this media at all lower temperatures and concentrations. Once chemical resistance has been established, the greatest loss in flexural strength will occur in the first six months for room temperature exposures and in two months for exposures at 212°F.

Although laboratory test data are fairly well correlated with plant experience, complete reliance should not be placed on laboratory data which are obtained under carefully controlled conditions. Whenever possible, a field-test program should be initiated because it will include the many production variables which are impossible to simulate in the laboratory. In all cases, care must be exercised to ascertain that only chemical-resistant polyester laminates are employed in chemical applications. Since there are many variables within the many polyesters available, minor differences in behavior are to be anticipated. Production equipment and accessories are made from composites that are cured either at room temperature or elevated temperature. Best results are obtained with those laminates which are given a postcure at the factory. On the other hand, satisfactory results are achieved when the room temperature compounds are used to assemble, modify or repair factory-made structures.

Reinforced polyester laminates are not a panacea for all the ills of industry. In this era of rapid technological advances, rising costs, tightening economy and keen competition, it is imperative that the proper and most economic material be selected for the job at hand. Polyester plastic is light in weight, strong and tough. It is readily fabricated into com-

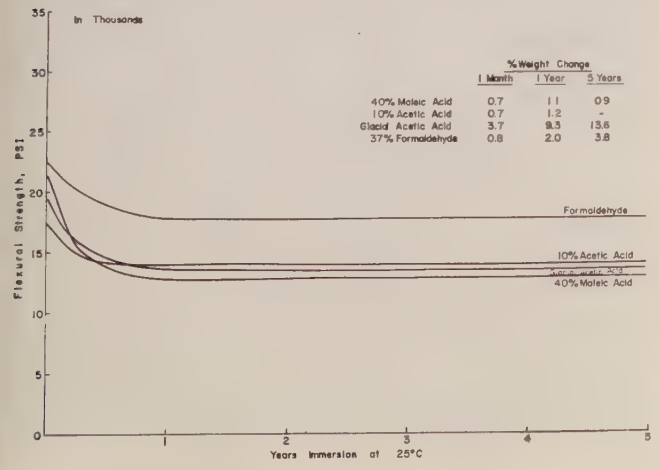
In Thousands
Flexural Strength, PSI
Years Immersion at 25°C
% Weight Change
1 Month 1 Year 5 Years
40% Maleic Acid 0.7 1.1 0.9
10% Acetic Acid 0.7 1.2 -
Glacial Acetic Acid 3.7 9.3 13.6
37% Formaldehyde 0.8 2.0 3.8
Formaldehyde
10% Acetic Acid
40% Maleic Acid

Fig. 6a

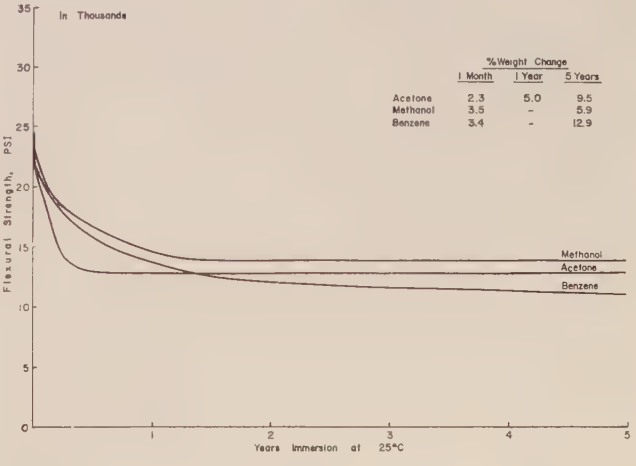

Fig. 7

plex shapes, and is easily installed and repaired. The maintenance costs are low and, since the surfaces are smooth, chemicals do not readily adhere and cleaning costs between batches and products are at a minimum.

The basic resin producers are continually improving their products and the fabricators are consistently extending the range of usefulness. Today, reinforced polyester plastics have a definite place in industry and are becoming increasingly important as a material of construction. They can be made into sheets, tubes and pipe and fabricated into tanks, towers, hoods, ducts, stacks, trays, filter plates, fume scrubbers, fans, blowers, and other tailor-made items. In many instances, reinforced polyester laminates have proved themselves to be superior to metals and other materials for process equipment containing corrosive chemicals.

PRESENTED at the Fifteenth Engineering Conference of the Technical Association of the Pulp and Paper Industry, held in Jacksonville, Fla., Oct. 23–27, 1960.

The author wishes to thank J. J. Fisher, American Cyanamid Co., Bridgeville, Pa., for making available the graphs used in this presentation.

A Blade Applicator for the I.G.T. Tester

WILLIAM J. HASELOW

It is the purpose of this paper to describe a new I.G.T. blade fluid application instrument and to present data for comparison of the blade and roller system methods of application of a fluid to the periphery of the I.G.T. disk. It is shown that the blade method is considerably faster and more convenient than the roller method of fluid application and that a direct correlation between the two methods exists.

FOR the past several years a great deal of work has been carried on investigating various methods of testing the bonding strength of coated papers. The Dennison wax test has been used for years but this test has two serious disadvantages; namely, "(1) in latex coatings, the waxes are solubilized by the adhesive vehicle so that the adhesive strength of latex coatings cannot be accurately determined, and (2) strength of the coatings cannot be defined in fundamental units" (*1*).

In 1946 The Institute of Paper Chemistry bonding strength tester was developed. This instrument was based upon the idea that when the periphery of a disk was covered with a thin film of viscous fluid and rolled over a surface the tensile stress exerted on the surface was proportional to the product of the viscosity of the fluid and the peripheral velocity of the disk (VVP) (*2*). Thus, it was contended that with a fluid of known viscosity the velocity at which the rupture of a test specimen takes place can be determined. This contention was later verified experimentally by Wink, Clinton, Thickens, and Van den Akker (*3*).

Since the I.P.C. bonding strength tester was conceived, the Institute for Graphic and Allied Industries of Amsterdam, Holland, has developed the I.G.T. printability tester. This instrument is based upon the principles of the I.P.C. bonding strength tester but is more compact and easier to operate. Both of these instruments have many limitations. However, the I.G.T. tester is presently considered one of the best available (*1*). Preference for the I.G.T. tester is primarily due to its ease of operation.

In addition to the limitations outlined by Hemstock and Swanson, there is one more limitation which is of tremendous importance. This factor is testing time. It is not of importance with respect to VVP values, but is of great importance with respect to use of the instrument. Application of the film of fluid to the disk using the I.G.T. film spreading device requires a great deal of time which prevents the I.G.T. test from becoming a useful control instrument (*1*).

Also, the I.G.T. test using glue glycerine rollers for ink application has not been as reproducible as desired. Perhaps some of the variability between tests is due to changes in the tack of the ink while on the rollers which is probably caused by the shearing stress applied at the nip and by oxidation of the ink on exposure to the atmosphere.

In an effort to substantially reduce the testing time and to improve the reproducibility of the I.G.T. test an instrument was designed for applying a uniform and measured film of fluid to the periphery of the disk (see Fig. 1). This is a blade type of applicator with a built in 0.0001 screw micrometer for measuring the thickness of the fluid film. This instrument is based upon the principle of the prefilm forming tool designed at The Institute of Paper Chemistry, but is substantially different in design and operational procedure (*4*).

It is the purpose of this report to describe this new instrument and to present data for comparison of the blade and film spreading methods of application of a fluid to the periphery of a disk.

EXPERIMENTAL DESIGN

The major purpose of this experimental work was to compare the results obtained using the blade applicator and the I.G.T. film spreading device (roll method) for applying a film of fluid to the periphery of the I.G.T. disk. From preliminary investigation using a crude blade applicator it seemed as if the blade method produced results which correlated well with those obtained using the roll method (glue-glycerine rolls) and which were more reproducible. This looked good; however, the design of this blade applicator was not satisfactory. For this reason the blade applicator show in Fig. 1 was designed and built.

The comparison of this new blade applicator with the glue-glycerine roll method was done quite simply. Samples of coated offset papers were obtained which had I.G.T. bonding

Fig. 1. The blade applicator

WILLIAM J. HASELOW, Quality Control Engineer, Consolidated Water Power and Paper Co., Wisconsin Rapids, Wis.

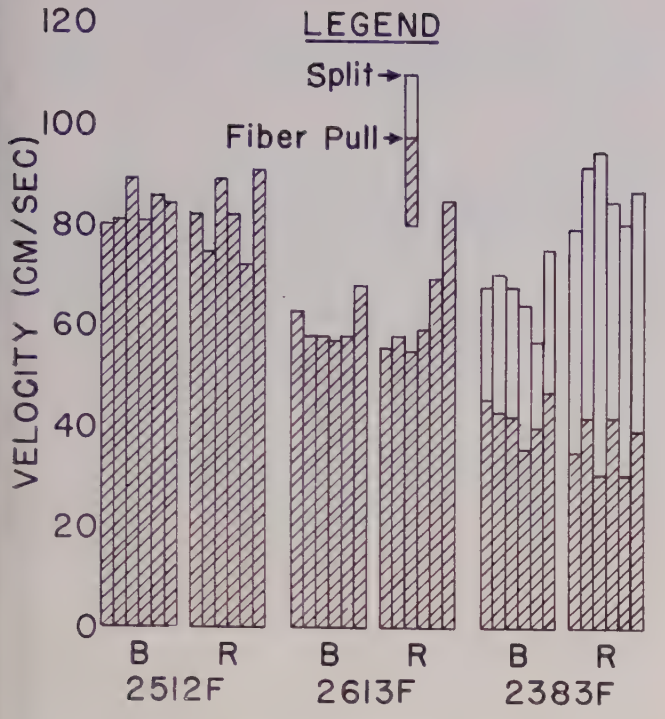

Fig. 2. Blade versus rollers—Trial I

strength ruptures ranging from approximately 40 to 113 cm. per sec. using I.P.I. no. 6 tack graded ink. These samples were then selected by means of random numbers and tested by both methods. Each test was replicated six times to give a measure of the standard error or reproducibility of results of each test method. The resultant data were then analyzed both visually and statistically.

BLADE APPLICATOR PROCEDURE

The operational procedure used for this new instrument is quite simple which is desirable from a quality control point of view. Any control tester could learn to use this tool quite easily. The procedure is as follows:

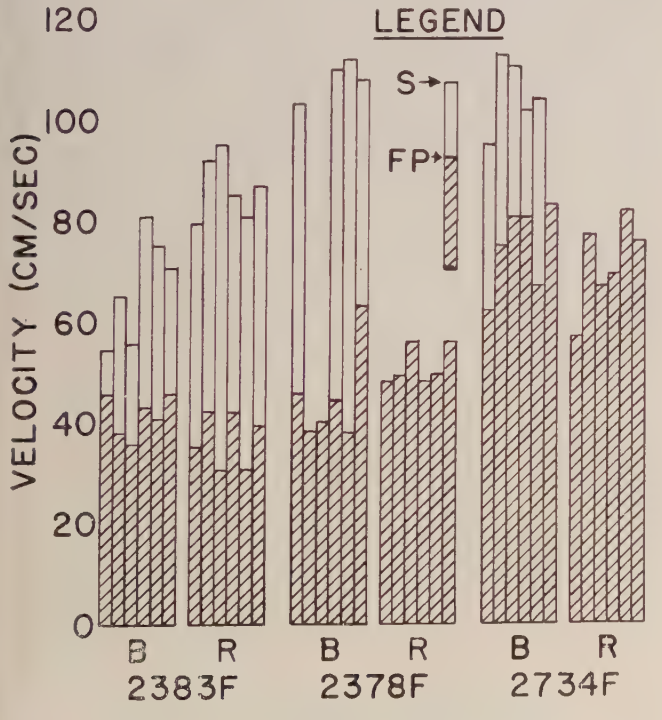

Fig. 3. Blade versus rollers—Trial II

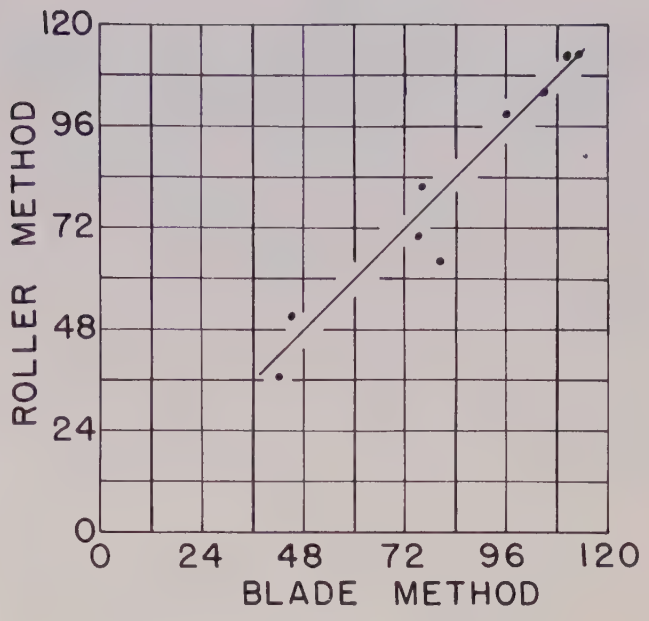

Fig. 4. Correlation between rupture velocities (cm./sec.) of blade and roller methods

1. Place the I.G.T. disk on the shaft of the blade applicator (see Fig. 1).
2. While turning the shaft and disk by means of the handle, apply a slight excess of the viscous fluid to the periphery of the disk with a spatula.
3. After a uniform film of fluid is obtained on the disk remove the excess fluid from the edge of the disk with the spatula.
4. Remove the disk and place it on the I.G.T. pick tester with the ridge of fluid at the beginning of the paper test specimen.
5. Activate the I.G.T. tester and evaluate the sample.

DISCUSSION OF RESULTS

One obvious advantage of the blade method over the roll method of applying ink to the periphery of the disk is the reduced testing time required. Without question the blade method is considerably faster than the roll method of fluid application. A comparison of the estimated time requirements for each method is as follows:

	Blade method, min.	*Roll method, min.*
Preparation	1	12
Testing	1	2
Washup	2	10
Total	4	24

These requirements are admittedly applicable only for single specimen testing and as the number of tests between washups is increased the time factor becomes less significant. Nevertheless, the testing time and ease of operation of the blade applicator are factors to be considered when comparing the two methods of fluid application. For I.G.T. bonding strength control testing the blade method has definite advantages.

The first evaluation of the blade and roll methods of fluid application seemed to substantiate the findings of preliminary investigation and the contention that the blade method produced more uniform and reproducible results than the glue-glycerine roll method. This is shown in Fig. 2. This apparent reduction in variability of the blade method, however, was not conclusive and a greater degree of variation existed than was desired.

Upon inspection of the blade instrument while rotating the disk it was obvious that the thickness of the film of ink being applied was varying greatly. This variation in ink film

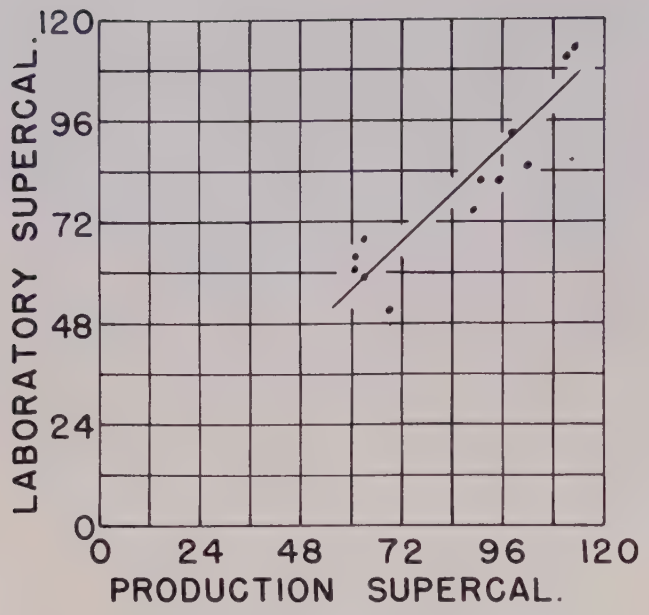

Fig. 5. Correlation between rupture velocities (cm./sec.) of production and laboratory supercalendered samples

thickness was found to be about 0.0005 in. This may not seem to be very much, but when working with ink film thicknesses of about 0.0005 to 0.0010 in. this variation becomes quite large. The effect that this had on the test results was not known, but it was decided that an improvement was advisable. In order to overcome this difficulty special precision bearings were installed. This substantially reduced the variation in ink film thickness obtained on the periphery of the disk.

The results of the second trial to determine the relative merits of the blade applicator as compared to the roller system are shown in Fig. 3. The results are again well correlated, but in this case the amount of variability experienced with each method was about the same. You will also notice that the test specimens tend to split more readily after a fiber pull has occurred using the blade method. In other words, the blade method produces more drastic ruptures of the test specimen. This I believe is a point in favor of blade application.

The correlation of the averages of six tests for each method is shown in Fig. 4. From a visual analysis of the data they are obviously well correlated, and this is substantiated by statistical analysis. The correlation coefficient (r) for these data was 0.9685 which means that 93.8% of the variability in one method is explained by the other. This relationship was also highly significant and this means that it is not very likely that this correlation occurred by chance.

PRACTICAL CONSIDERATIONS

The development of the blade applicator, with its reduced testing time, has opened up the possibility of I.G.T. bonding strength control testing at the paper machine. Samples obtained at the paper machine could be laboratory supercalendered and tested for I.G.T. bonding strength. Preliminary investigation of this procedure indicates that a fairly good correlation exists between production and laboratory supercalendered samples. This relationship is shown in Fig. 5.

CONCLUSIONS

Blade application of ink to the periphery of the I.G.T. disk is considerably faster than ink application with the roller system. This is advantageous from a quality control point of view and makes I.G.T. bonding strength control testing more feasible.

The correlation between blade and roller ink application I.G.T. bonding strength data is very good which means that blade application can be substituted for the roller inking system directly.

The variation between tests was somewhat less with the blade application method than with the roller system.

The design of the blade instrument is not entirely satisfactory, especially for research purposes; however, for quality control purposes the instrument as presently designed is adequate.

LITERATURE CITED

1. Henstock, G. A. and Swanson, J. W., *Tappi* 40: 794–801 (1957).
2. Staff of The Institute of Paper Chemistry, Instrument Studies. LV. Determination of the Bonding Strength of Paper. I. Progress Report on the Development of a New Method, *Paper Trade J.* 123, No. 18: 24, 26, 28, 29; No. 19: 24, 26, 28, 30, 32, 34 (Oct. 13, Nov. 7, 1946).
3. Wink, W. A., Clinton, T. J., Thickens, R. W., and Van den Akker, J. A., Instrument Studies. LXXIV. Determination of the Bonding Strength of Paper. IV. Progress Report on the Development of a New Method and New Instrument, *Tappi* 35: 181A–188A (1952).
4. Wink, W. A., Shillcox, W. M., and Van Eperen, R. H., Instrument Studies. LXXX. Determination of the Bonding Strength of Paper. V. Progress Report on the Development of a Prefilming Technique and on a Study of the Specimen Backing Material, *Tappi* 40: 189A–199A (July, 1957).

A. C. J. West Memorial paper presented at the meeting of the Lake States Section of TAPPI, held in Neenah, Wis.

Steam Cooking of Northern Hardwoods

DAVID A. FEIGLEY and
MERLE J. SHOWALTER

As controls for a proposed study of the semichemical pulping of the hardwood species available in northern New York, a series of steam cooks were performed duplicating the conditions assumed to occur in an Asplund-type cooker. The cooked woods were evaluated by disintegration through a disk mill and subsequent beating for one hour in a standard Valley beater. Surprisingly it was found that, with certain species, cooks of 5 to 10 min. at 150 p.s.i. steam pressure produced pulps the equivalent in strength development to fully cooked chemical pulps. The studies indicated that such results could be obtained only with a vapor phase cook and that the strength development correlated with the pH of the cooked chips, the optimum pH for maximum strength development falling about 3.5 ± 0.2. At higher pH's no such strength development was obtained while lower pH's led to degradation of the base cellulose fibers. It was postulated that organic acids of particular acid strength, either originally present or produced by steam hydrolysis, were responsible for the unexpected strength developments. This theory was at least partly confirmed by treating wood species unresponsive to the steaming process with selected organic acids, thus causing marked improvements in strength development.

For the past 12 years the Fulton plant of the Armstrong Cork Co. has produced a pulp, commonly known as Asplund, from mixed hardwoods. Such pulp is used as a cheap diluent in rag furnishes to produce flooring felts such as linoleum backings and industrial felts such as sheathing. Such a pulp is produced in an Asplund-type cooker by a short steaming cycle at 100 to 150 p.s.i. and subsequent disintegration, still under steam pressure, with a single disk defibrator.

Asplund pulp is typically coarse, stiff, and bulky, with no ability to hydrate during mechanical refining. It cannot be

David A. Feigley and Merle J. Showalter, Chemists, Research and Development Center, Armstrong Cork Co., Lancaster, Pa.

used by itself to produce a paper or felt product since it fails to develop sufficient strength during wet formation to carry through the paper machine. These properties also limit the amounts that can be used as filler or diluent to less than

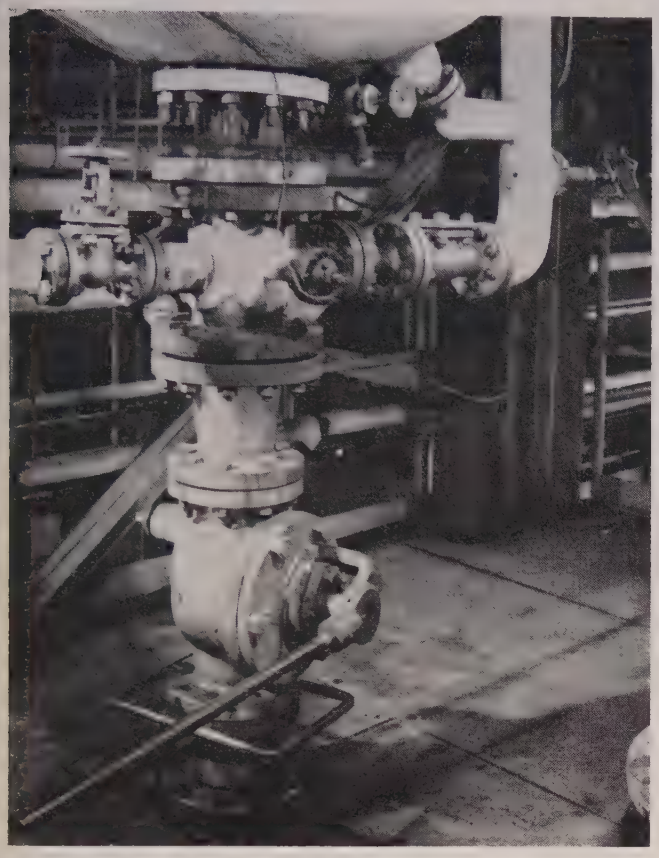

Fig. 1. Photograph of Digester

50% by weight, even when the strength qualities of the finished product are not of critical importance.

Because of the variability of rags as a raw material, as well as the possible savings in cost involved, it had long been hoped to improve the quality of fibers produced from hardwoods so as to increase the amount usable in our felt products. Semichemical pulping, as described in the literature over the past decade, seemed to be the possible answer to our problem.

A few preliminary bench experiments using complete immersion of chips in dilute caustic soda at atmospheric pressure and at various temperatures soon convinced us of the value and feasibility of semichemical pulping with the species of hardwoods available to us. A thorough engineering study led to the installation of a 10 cu. ft. rotating digester capable of withstanding 300 p.s.i. pressure. This equipment, along with a 24-in. Bauer double-disk refiner and a 2 ft. wide pilot

Table I. Pulp Strength of Steam Cooked Aspen

Chip type	*Tensile, p.s.i.*	*Density, lb./cu. ft.*
Brown	3530	42.8
White	460	24.4

plant fourdrinier paper machine, put us in a position to study intensively both the pulping process and the ultimate utilization of the resulting fiber.

Initially we appeared to work under a handicap because our technical people, although well acquainted with the production of thick sheets on both fourdrinier and single-cylinder felt machines, had no practical experience either in full chemical or semichemical wood cooking. For this reason we set up a rather elaborate set of control experiments to separate variables such as cooking temperature, chemical types, chemical concentration, and cooking time. As a result of some of these control experiments we have diverged considerably from the process commonly known as semichemical pulping.

Based on information from our factory, it seemed obvious

Table II. Pulp Strength of Steam Cooked Wood Species

Wood species	*Tensile, p.s.i.*	*Density, lb./cu. ft.*
Cherry	4270	41.0
Aspen	4310	44.2
Maple	2850	32.5
Yellow birch	4350	42.0
Elm	785	22.9
Basswood	400	22.8

that the Asplund process was substantially a vapor phase cook in steam; so our first step was to cook a small amount of aspen chips in steam only, to establish a control point. The procedure was to preheat the digester with 150 lb. steam, add chips, steam for 5 min., and blow down. It was noticed immediately on initial cooks with aspen that the steamed chips were a mixture of soft darkened material and a hard, light-colored chip almost identical to the original uncooked wood. Obviously the light-colored chip had not been attacked by steam.

Thus, before proceeding with further work on chemical

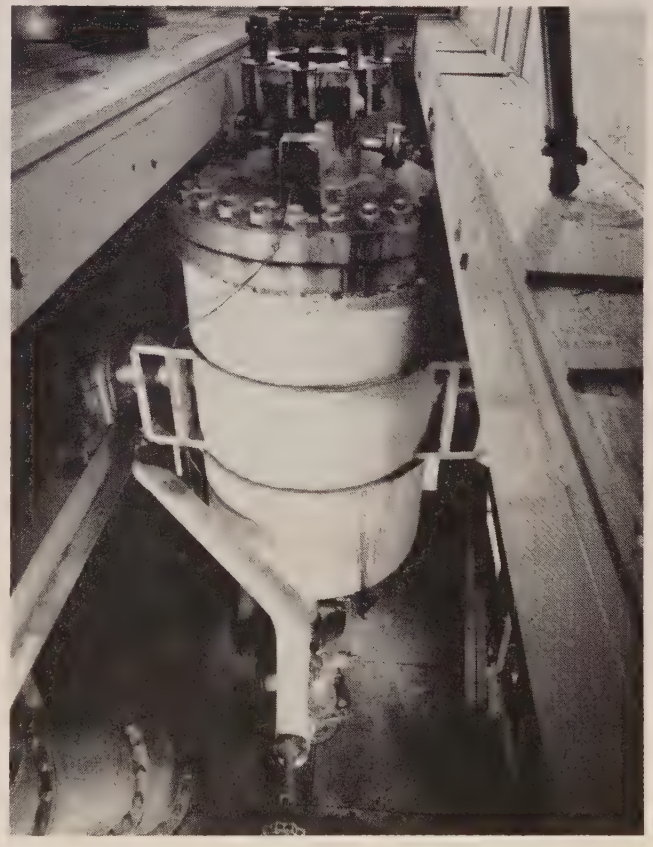

Fig. 1A

additives, it became our primary problem to find out why some of the chips were not cooked. Without describing the considerable amount of initial fumbling, the answer came out as indicated in Fig. 1.

Because the digester was not rotated in the initial experi-

ments and because of insufficient preheating, it was suspected that steam was condensing and partially submerging the chip charge. The brown fraction of the chips was that exposed to the steam, while the white fraction was that immersed in the water.

Experiments were devised to investigate this hypothesis.

Table III. Effect of Citric Acid on Pulp Strength

Specie	% Citric acid on weight of wood	Tensile strength	
		Steam cooked	Acid cooked
Cherry	....	4270	....
Cherry	10	....	625
Basswood	....	400	....
Basswood	10.2	....	2030
Basswood	14.1	....	3250
Basswood	23.0	....	545

After intensive preheating of the digester a small amount of aspen chips was put in and steam cooked for 5 min. at 150 p.s.i. When these chips were blown down, it was found that they were all soft and brown in color. In another experiment water was placed in the digester above the steam inlet and then a small amount of aspen chips was added. Upon completion of the steam cook the chips were blown down and found to be hard and light in color.

The two types of chips were refined by defiberizing through the Bauer refiner at a 0.075 in. plate setting and then beaten

Table IV. Effect of Maleic Acid on Pulp Strength

Specie	% Maleic acid on weight of Wood	Tensile strength	
		Steam cooked	Acid cooked
Cherry	....	4270	....
Cherry	3.4	....	1342
Basswood	....	400	....
Basswood	1.25	....	1060
Basswood	2.5	....	3105
Basswood	5.0	....	3050
Basswood	7.5	....	545

for 1 hr. in a standard 1-lb. Valley beater. At the end of this refining cycle, handsheets were formed and tested for tensile strength and density with the results shown in Table I.

The steam cook on aspen in which the water in the digester was virtually eliminated produced an excellent, although dark colored, high strength pulp.

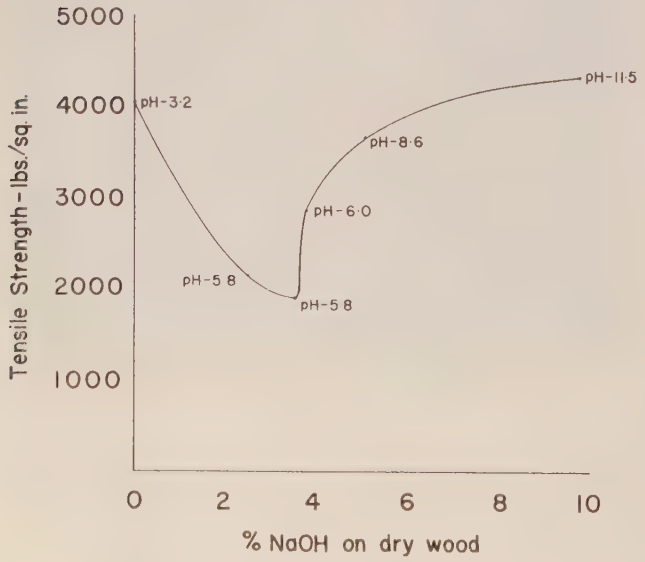

Fig. 2. Pulp strength (T.S.) versus % NaOH on cherry

Once the optimum steaming cycle for aspen was established, the same procedure was applied to the other species of wood used at our factory. Not unexpectedly, the results varied widely with the species (Table II).

At this point it was obvious that by adjusting the cooking conditions properly and by using selected species of wood, a tremendous improvement in wood pulp quality could be achieved at the factory level. However, selection of wood by species threatened to increase our cost per cord and work was continued on possible reaction mechanisms that might account for our results.

Concurrent work done with various percentages of caustic under the same cooking conditions indicated that addition

Table V. Effect of Phthalic Acid on Pulp Strength

Specie	% Phthalic acid on weight of wood	Tensile strength	
		Steam cooked	Acid cooked
Basswood	....	400	....
Basswood	7.9	...	2365
Basswood	10.0	...	1770

of caustic soda from 0–3.5% on the weight of the wood reduced the pulp strength on certain species (Fig. 2).

As the percentage of caustic soda was increased above 3.5% the pulp strength increased until, at 8 to 10% NaOH on the weight of wood, the pulp strength was equivalent to that of steam cooked wood. In fact, 8 to 10% NaOH invariably gives good results regardless of species.

On the basis of these comparisons it was concluded that organic acids of particular acid strength, either originally present in the wood produced *in situ* by steam hydrolysis, were responsible for the unexpected strength developments. These acids neutralize small amounts of caustic soda, thus accounting for reduced pulp strength on addition of caustic soda from 0 to 3.5% on the weight of the wood. A number of acids were tried; among them were acetic, formic, maleic, citric, and phthalic acids. An acid solution was sprinkled over basswood chips, a specie which when cooked with steam only has poor pulp strength. The chips were mixed and then put in the digester and steam cooked for 5 min. at 150 p.s.i. Neither acetic nor formic acid increased pulp strength significantly. However, it was found that maleic, citric, and phthalic acids increased pulp strength considerably. Results of experiments on the use of the acids are given in Tables III, IV, and V.

It is seen that, when cherry was treated with either citric or maleic acid, the cellulose was degraded and pulp strength decreased. It is postulated that there is sufficient organic acids, either originally present in cherry or produced *in situ* by steam hydrolysis, to produce high pulp strength, and addition of more acid to cherry will decrease pulp strength. On the other hand, basswood apparently does not contain these acids in sufficient quantity so that when it was treated with an acid of particular acid strength, such as citric, maleic, or phthalic, the pulp strength improved up to the point where the acid addition was excessive.

CONCLUSION

Based on the presented data a number of tentative conclusions have been drawn.

1. A short cooking time with development of excellent pulp strength is possible for all hardwood species, provided knowledge of wood acidity is available.

2. Since the cooking procedure is essentially a vapor phase cook, there is little or no effluent to present a problem of disposal.

3. It is felt that the large differences in results with steam alone due to pH effects may correlate with variations caused by different species in more typical semichemical and full chemical pulping processes.

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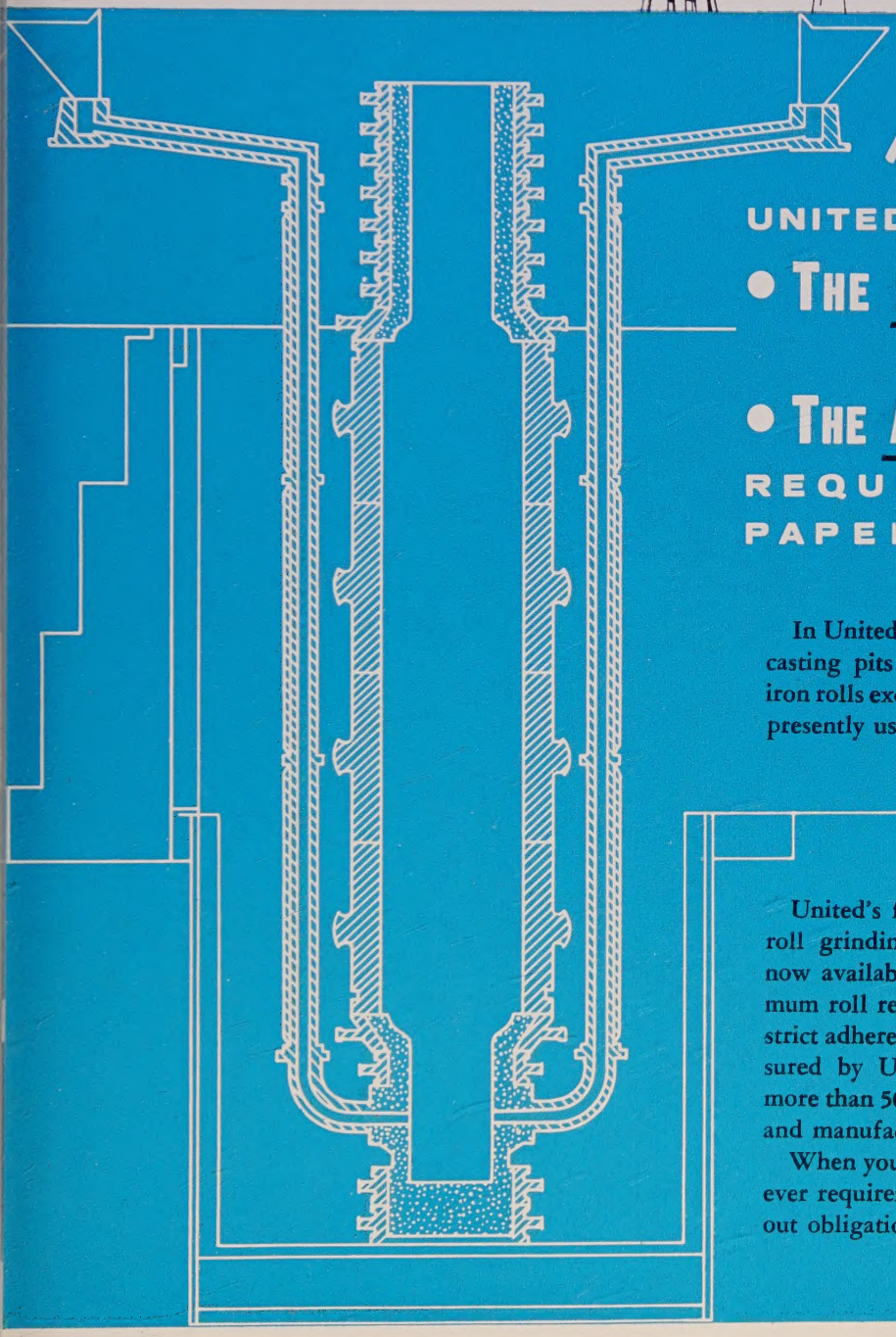

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